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MASTER MONITOR DISPLAY

APPLICATION STUDY – F-14

Power, Optics & Displays Dept.
Grumman Aerospace Corporation
Bethpage, New York 11714

25 March 1977

Final Report

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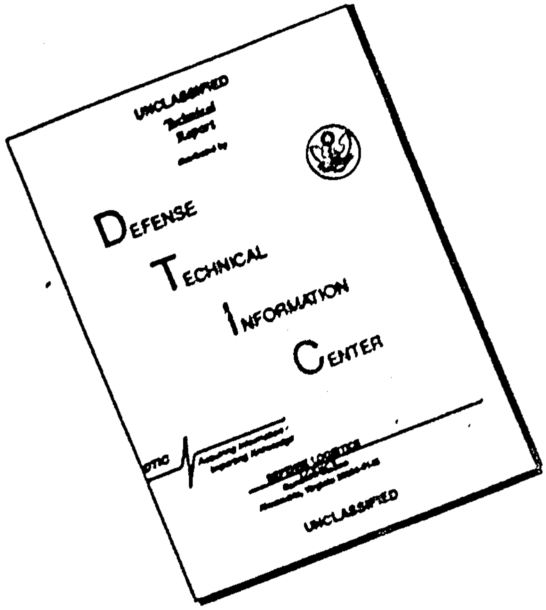

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Report summarizes the results of a study to replace the existing Caution Advisory Indicator in the F-14 with a Master Monitor Display (MMD). An MMD is described which uses the existing F-14 fault sensors with a few additions, and with several minor modifications to the aircraft interface. The MMD design features "management by exception", and provides automatic display of fault and course of action information on a cathode ray tube readout for all detected faults. It also provides for manual display of total systems status, system fault, and fault history information on a call up basis.

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INTRODUCTION AND SUMMARY

INTRODUCTION

This report is submitted in compliance with Item A002, Exhibit A, of Contract N62269-76-C-0199. This application study final report considers the feasibility of replacing the existing F-14 Caution Advisory Subsystem with a Master Monitor Display (MMD). This study shows that it is entirely feasible to incorporate an MMD into the F-14 aircraft, in spite of the fact that the F-14 is in the advanced stage of production. Moreover, this addition would enhance the pilot's effectiveness as manager of a number of highly complex aircraft systems. This is accomplished by reducing the pilot's workload, particularly during times of crisis.

In any aircraft, some means of monitoring the inflight operating status of those systems that are required to maintain and ensure safe flight is necessary. In the past, and particularly in the F-14, this need has been met by use of a Caution Advisory Indicator (CAI). The CAI receives discrete information (go/no-go) from a number of sensors located in the various systems throughout the aircraft. In the event of no go conditions, CAI circuits are activated, lighting appropriate backlighted legends and furnishing readable messages to the crew. Over the years, as aircraft and systems technology have grown more and more complex, the task of monitoring, and particularly of displaying the proper malfunction message has become more and more difficult for the CAI method.

The advances in technology demand a computerized display which would not only indicate out-of-tolerance conditions or malfunctions, but which could make decisions based upon multiple parameters, and display the proper message for the situation. Therefore, this message should accurately summarize the situation and, in addition, it should provide the appropriate required action on the part of the crew. Such are the functional requirements of the MMD. In order to fully exploit the capability of such a display, the on-board systems must be computer managed, providing a variety of information such as degree of degraded performance, mode, back up modes available, etc., as opposed to the discrete go/no go information of the CAI system described. This information would be supplied to the MMD via a data buss such that discrete wiring would be held to a minimum. All signal information would be in the same digital word format.

This study considers the feasibility of replacing the existing F-14 CAI with a practical MMD. Toward that end, an MMD has been proposed that meets the stated functional requirements without the computerized input signal information and features. The reason for not computerizing the MDD is that its incorporation would require extensive redesign of the F-14. The recommended approach represents the most practical solution to development and flight test of an MMD for the F-14 aircraft.

The three major tasks outlined in the Contract Statement of Work are arranged and discussed as discrete packages. Therefore, Task 1 contains and discusses those items listed under Task 1 of the Statement of Work. Tasks 2 and 3 contain and discuss their respective statement of work items. The following summary briefly describes the proposed F-14 MMD.

SUMMARY

The following is a summary of the features of the proposed MMD: For reasons of practicality, an MMD is proposed for the pilot only in the F-14. This MMD uses a cathode ray tube (CRT) as a readout, and automatically displays fault and required action for all detected faults in page format. In addition, if the detected fault is a caution, a master caution indication is provided. Since the recommended approach is to retain all of the present warning indications in the F-14, no such master warning indication is provided.

The MMD allows the pilot to manually select the following displays:

- All system status
- A single system with status of its subsystems
- Fault information for all faults contained in a selected system
- Fault history.

The MMD incorporates a priority feature which provides that warning displays have priority over all other displays and automatic displays (detected faults) have priority over all manually selected displays.

TASK 1

Task 1 contains the following:

- Table 1 lists the existing F-14 input signals that will be available to the MMD. Table 1 also provides the conditions specified for each signal. The first 47 signals listed are in the front cockpit and are used for the pilot's CAI. Signals 48 through 61 are located in the rear cockpit and are used for the NFO's CAI.
- Table 2 lists the F-14 mission modes. The Pilot's Display Control Panel is shown in Figure 1. The Head-Up Display (HUD) and Vertical Display symbols for the various modes are shown in Figure 2 through 22.
- An F-14 sensor block diagram is shown in Figure 23. The F-14 Caution Advisory Indicator front panel is shown in Figure 24.

TABLE 1. INPUT SIGNALS TO F-14A CAUTION-ADVISORY INDICATOR (PILOT)

Signal	Type	Conditions
1. L Fuel Low	(C)	Legend Not Illuminated (Go): Open Circuit Legend Illuminated (No Go): +28 (+7.0, -4.6) vdc, 10 MA
2. R Fuel Low	(C)	
3. Bingo		
4. L Ramps	(C)	
5. R Ramps	(C)	
6. Oxygen Low	(C)	
7. L Inlet	(C)	
8. R Inlet	(C)	
9. L Ovsp/Valve	(C)	
10. R OVSP/Valve	(C)	
11. L Oil Hot	(C)	
12. R Oil Hot	(C)	
13. L Gen	(C)	
14. R Gen	(C)	
15. Ladder	(C)	
16. Bleed Duct	(C)	
17. L Fuel Press.	(C)	
18. R Fuel Press.	(C)	
19. Canopy	(C)	
20. Inlet Ice	(C)	
21. Hyd Press.	(C)	
22. Trans/Rect	(A)	
23. Wshld Hot	(A)	
24. Launch Bar	(A)	
25. Rudder Auth	(C)	Legend Not Illuminated: +4.5 ±0.5 vdc (Go) Legend Illuminated: 0.0 (+0.5, -0.0) vdc (No Go) Source Impedance: Not Illum-Less Than 100 Ohms Illum -0.0 Ohms to Open Circuit Load: 5K Ohm Min in Parallel With 5000 PFD Max
26. Spoilers	(C)	
27. Auto Pilot	(C)	
28. Yaw Stab. Op	(C)	
29. Pitch Stab. 1	(C)	
30. Roll Stab. 1	(C)	
31. Yaw Stab. Out	(C)	
32. Pitch Stab. 2	(C)	
33. Roll Stab. 2	(C)	
34. Hz Tail Auth	(C)	
35. Mach Trim	(A)	
36. CADC	(C)	Provide Voltage (+12v Min, +28v Max) for Collector of NPN Transistor for Conditions: Legend Off: Saturated (Less Than 0.4 vdc) 10 ma Sink Current Legend On: Open (Cutoff Transistor) 25 μamp Max Leakage
37. Flaps	(C)	
38. Glove Vane	(C)	

TABLE 1. INPUT SIGNALS TO F-14A CAUTION-ADVISORY INDICATOR (PILOT) (Cont)

Signal	Type	Conditions
39. Oil Pressure	(C)	Legend Not Illuminated: Open Circuit Legend Illuminated: Ground (A/C Gnd)
40. AHRS	(A)	↓
41. Integ Trim	(A)	↓
42. Wing Sweep	(A)	Legend Not Illuminated: Ground (A/C Gnd) Legend Illuminated: Open Circuit
43. Alt Low*	(A)	Legend Not Illuminated: Open Circuit Legend Illuminated: + 28vdc (Not Used)
44. Reduce Speed*	(A)	Legend Not Illuminated: Saturated Transistor to Ground (Less Than 4 vdc) Legend Illuminated: Open (Transistor Cutoff) 25 μ amp max leakage
45. Wing Sweep*	(W)	Activated From Either or Both Inputs Input 1. Legend Off: Saturated Transistor to Ground (Less Than 0.4 vdc) Legend On: Open (Cutoff Transistor) 25 μamp Leakage Max Input 2, Legend Off: Return to A/C Ground Legend On: Open Circuit
46. Auto Throttle*	(C)	Legend Off: Open Circuit Legend On: Ground, 45 ma, Max Sink Current
47. Wheels*	Warning)	Legend Off: Open Circuit Legend On: Return to A/C Ground Flashes On & Off (Square Wave, 4 pps)

In addition, the following signals are used and are available:

- Dimming Signal (Discrete) + 28vdc
- Test Signal (Discrete) + 28vdc
- Master Caution Reset Ground (Ov)

Signal	Type	Conditions
48. Film Low	(A)	Legend Not Illuminated (Go) - Open Circuit **
49. RDR Enabled	(C)	Legend Illuminated (No Go) - + 28 (+ 7.0, -4.6) vdc - 20 Milliamps Max **
50. C&D Hot	(C)	↓ **
51. Cooling Air	(A)	↓ **
52. Fuel Low	(C)	↓ **
53. Cabin Press.	(C)	↓ **
54. MSL Cond	(A)	↓ **
55. Canopy	(C)	↓ **
56. Oxy Low	(C)	↓ **
57. AWG-9 Cond	(A)	↓ **
58. Nav Comp	(A)	Legend Not Illuminated (Go) - Open Circuit **
59. AHRS	(A)	Legend Illuminated (No Go) - Ground (A/C Gnd) **
60. Fuze HV	(C)	**
61. IMU	(A)	Legend Not Illuminated (Go) - Ground (A/C Gnd) Legend Illuminated (No Go) - Open Circuit **

* Remotely located from CAI

** Signals numbered 48 through 61 are located in the rear cockpit and are used for the NFOs CAI

TABLE 2. F-14 MISSION MODES

Mode	Submode
1. Takeoff	A. Tacan B. Manual
2. Cruise	A. Vector B. Tacan C. Destination D. Manual
3. Air-to-Air Attack	A. Manual Gun B. Sidewinder (AIM-9) C. Sparrow Boresight (AIM-7) D. Sparrow Normal (AIM-7) E. Phoenix Normal F. Phoenix Boresight
4. Air-to-Ground Attack	A. Computer-Target or IP B. Computer-Pilot (Bombs) C. Computer-Pilot (Gun/Rockets)
5. Landing	A. Vector B. Manual C. Tacan D. ILS E. ACL

- Modes are selected by activation of mode select switches (Figure 1).
- Switches illuminate when selected indicating operating mode
- Pilot also knows mode by displays presented on VDI and HUD
- Various displays for each mode are shown in Figures 2 through 22

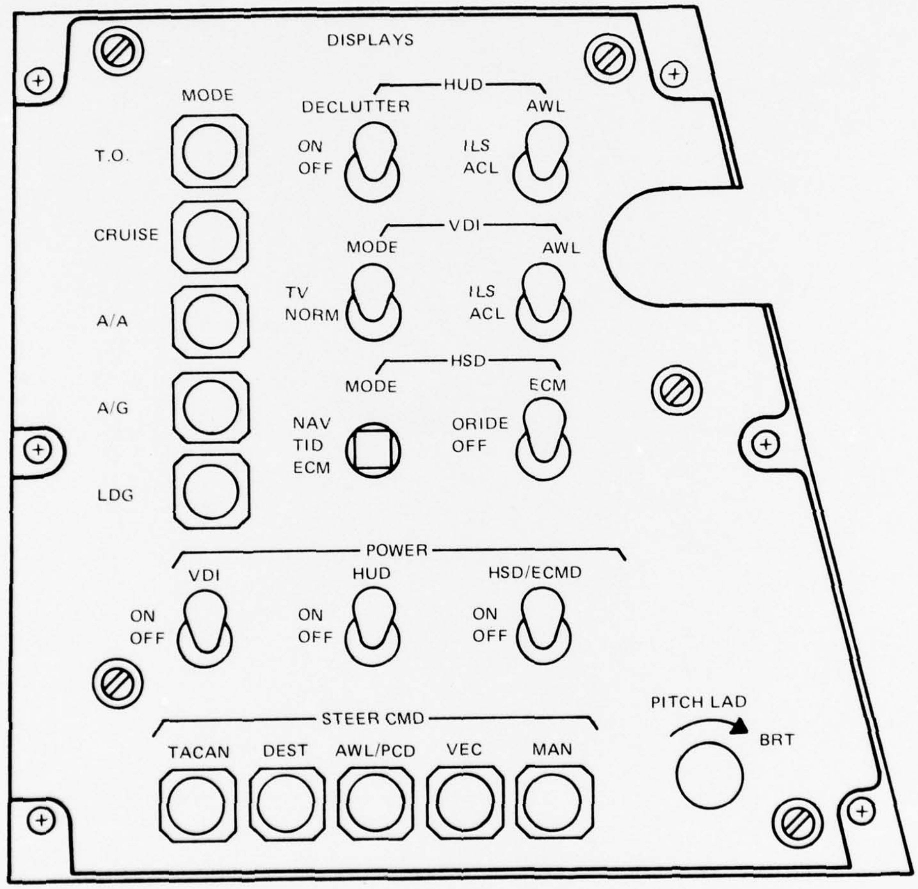
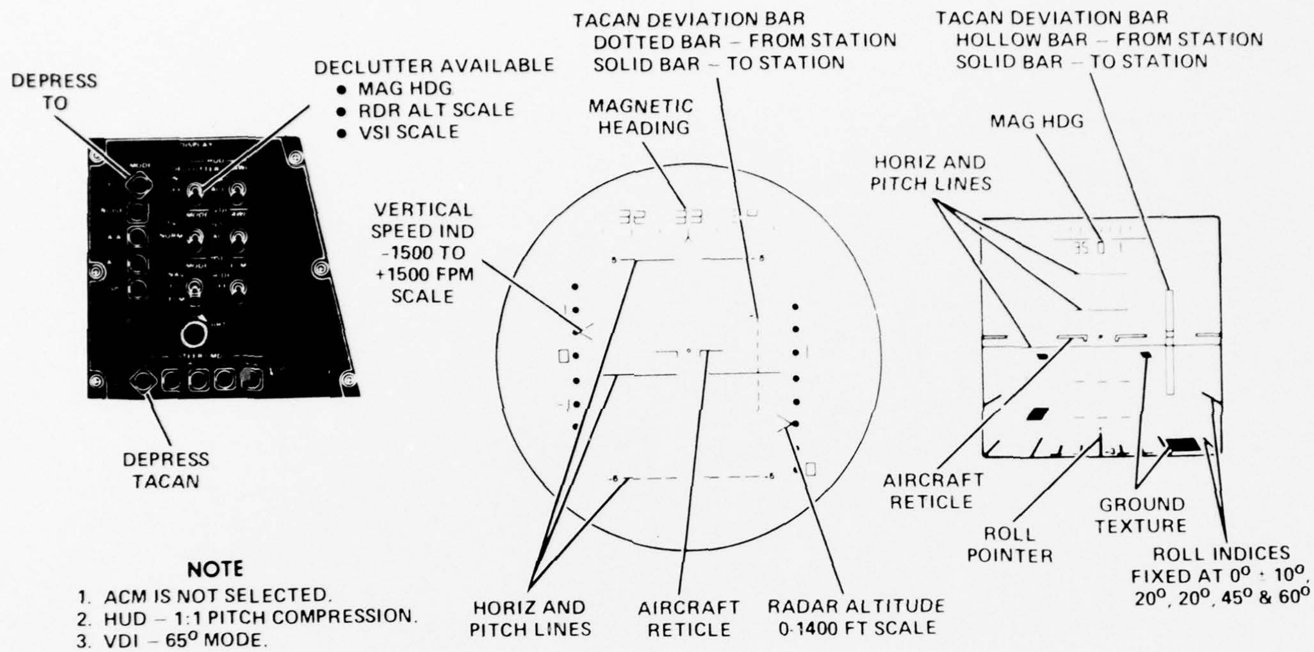


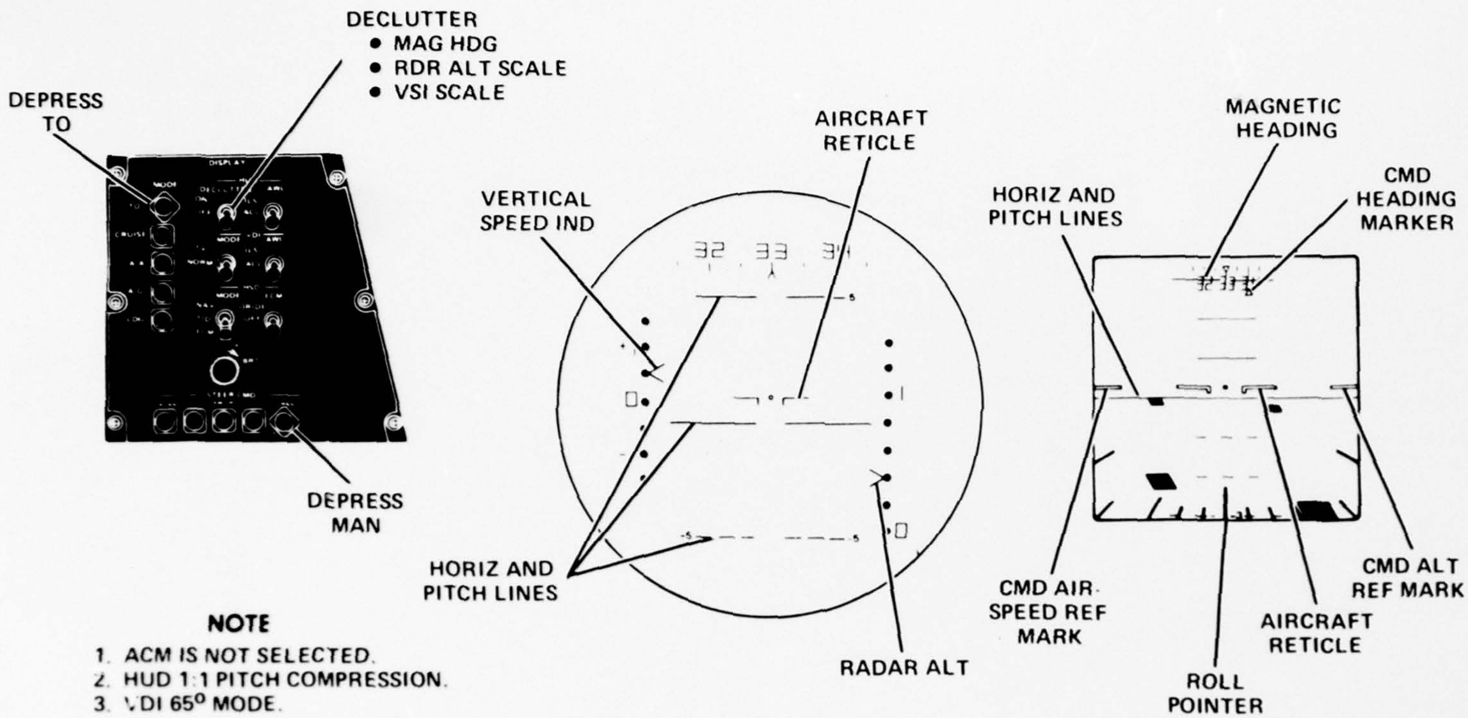
Figure 1. Pilot Display Control Panel



NOTE

1. ACM IS NOT SELECTED.
2. HUD – 1:1 PITCH COMPRESSION.
3. VDI – 65° MODE.

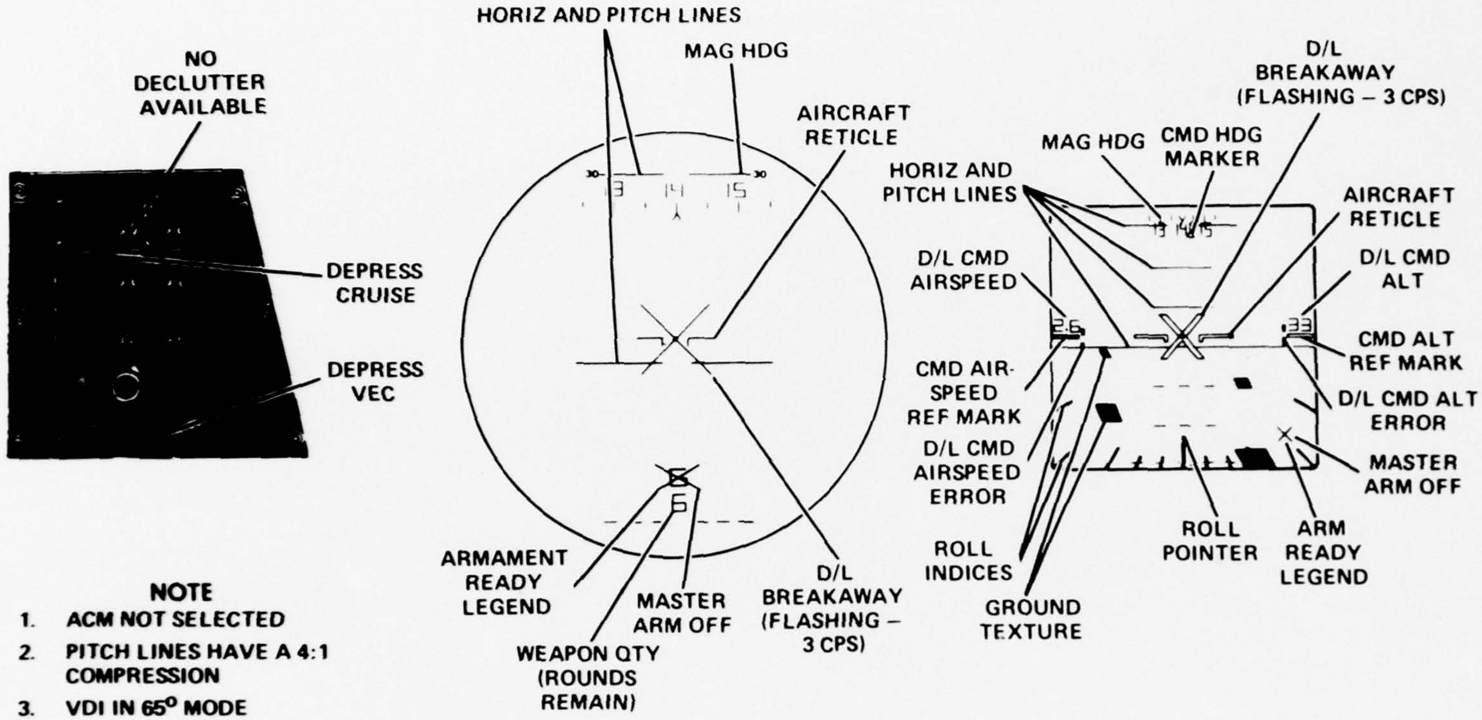
Figure 2. Takeoff Mode/TACAN Submode



NOTE

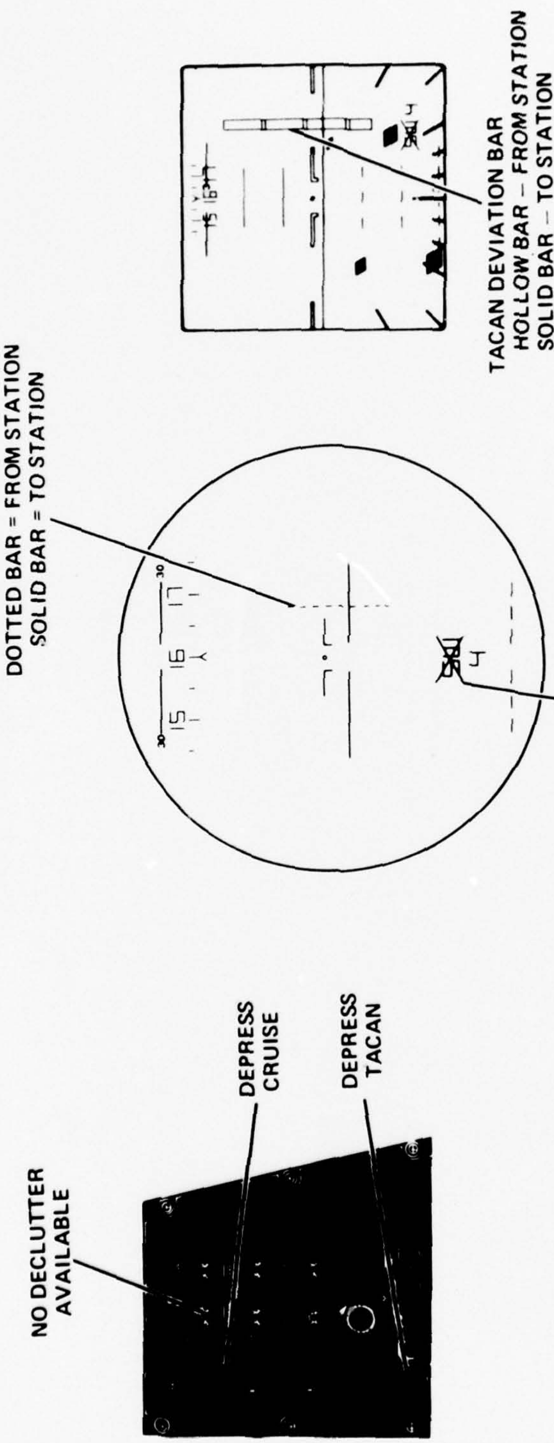
1. ACM IS NOT SELECTED.
2. HUD 1:1 PITCH COMPRESSION.
3. VDI 65° MODE.

Figure 3. Takeoff Mode/Manual Submode



NOTE
1. ACM NOT SELECTED
2. PITCH LINES HAVE A 4:1 COMPRESSION
3. VDI IN 65° MODE

Figure 4. Cruise Mode/Vector Submode



NOTE

1. ACM NOT SELECTED
2. PITCH LINES HAVE A 4:1 PITCH COMPRESSION
3. VDI IN 65° MODE

Figure 5. Cruise Mode/TACAN Submode

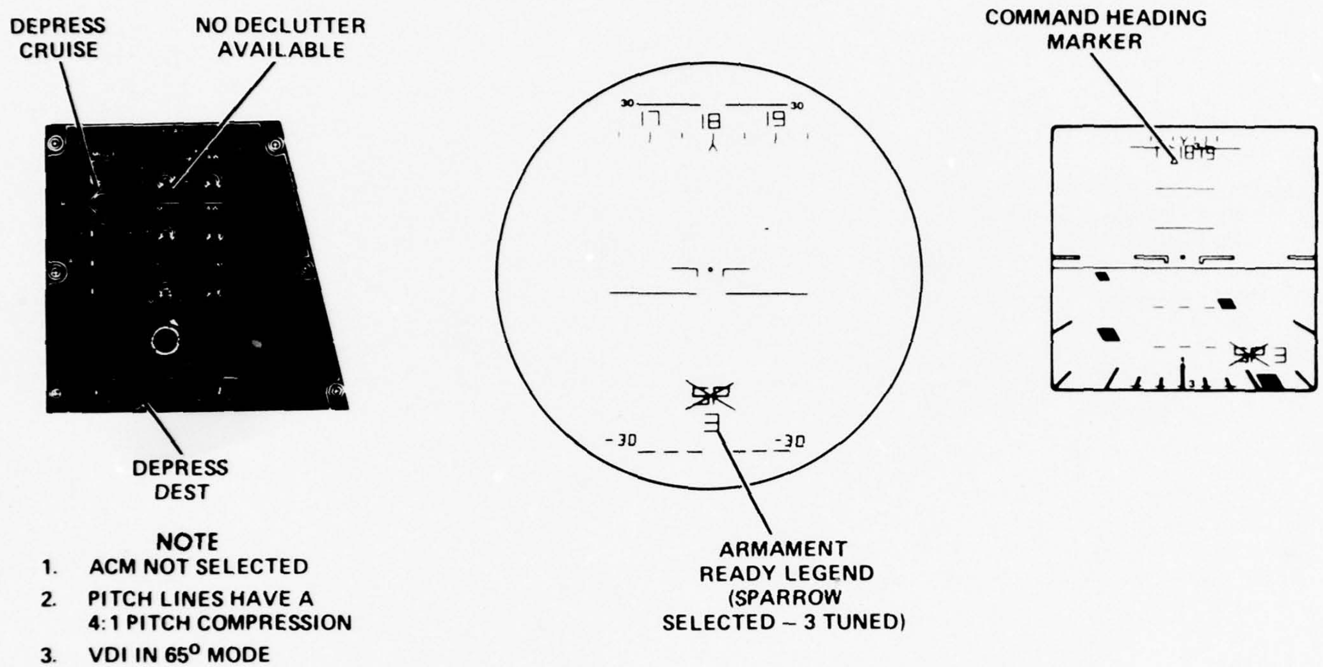


Figure 6. Cruise Mode/Destination Submode

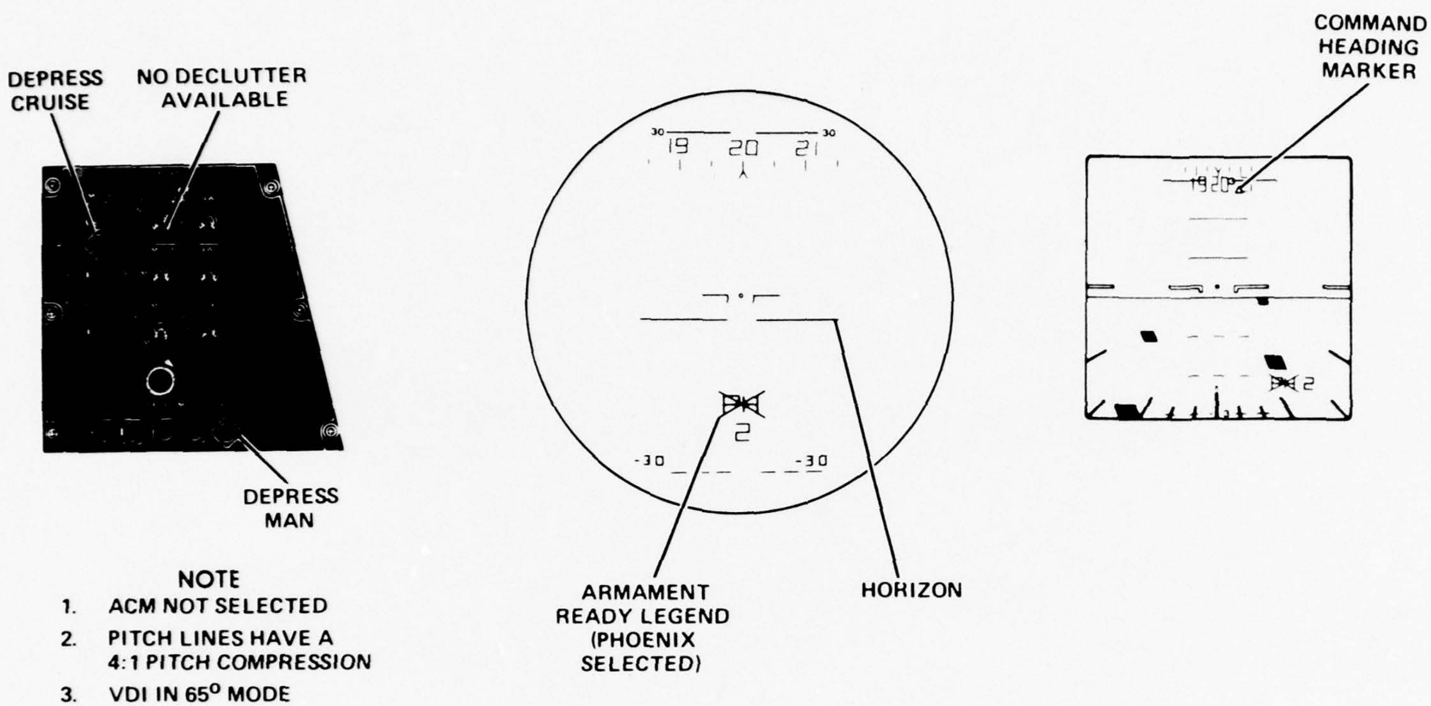


Figure 7. Cruise Mode/Manual Submode

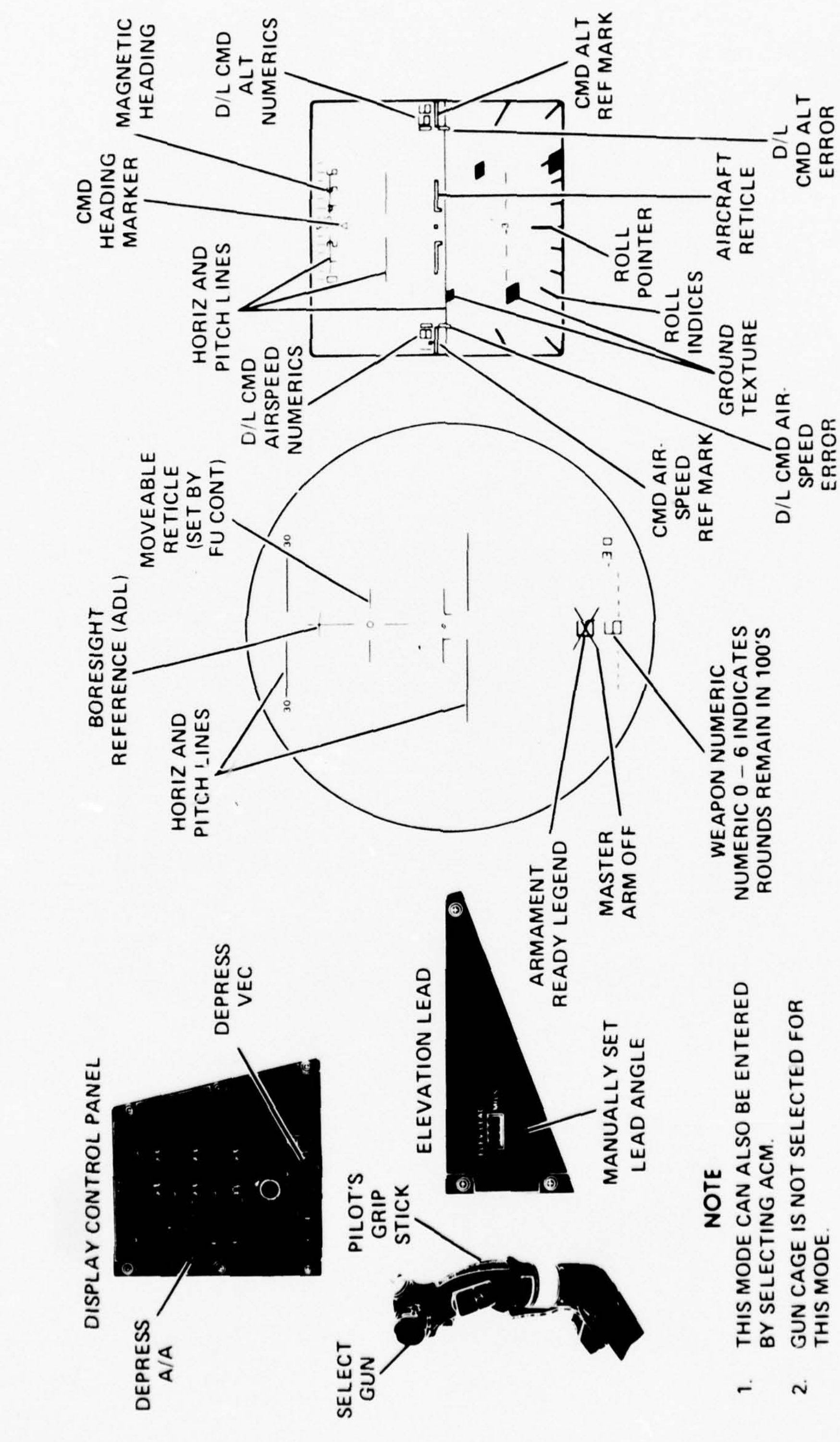
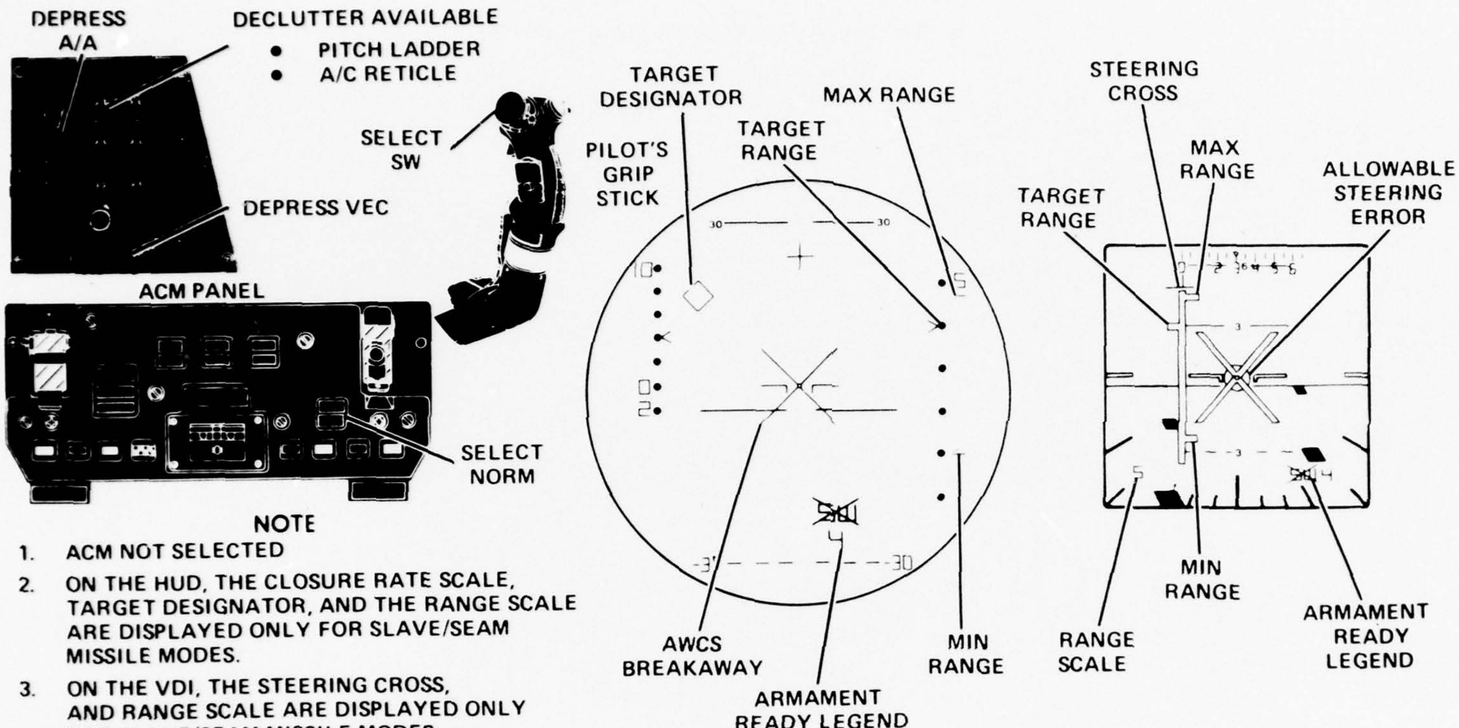


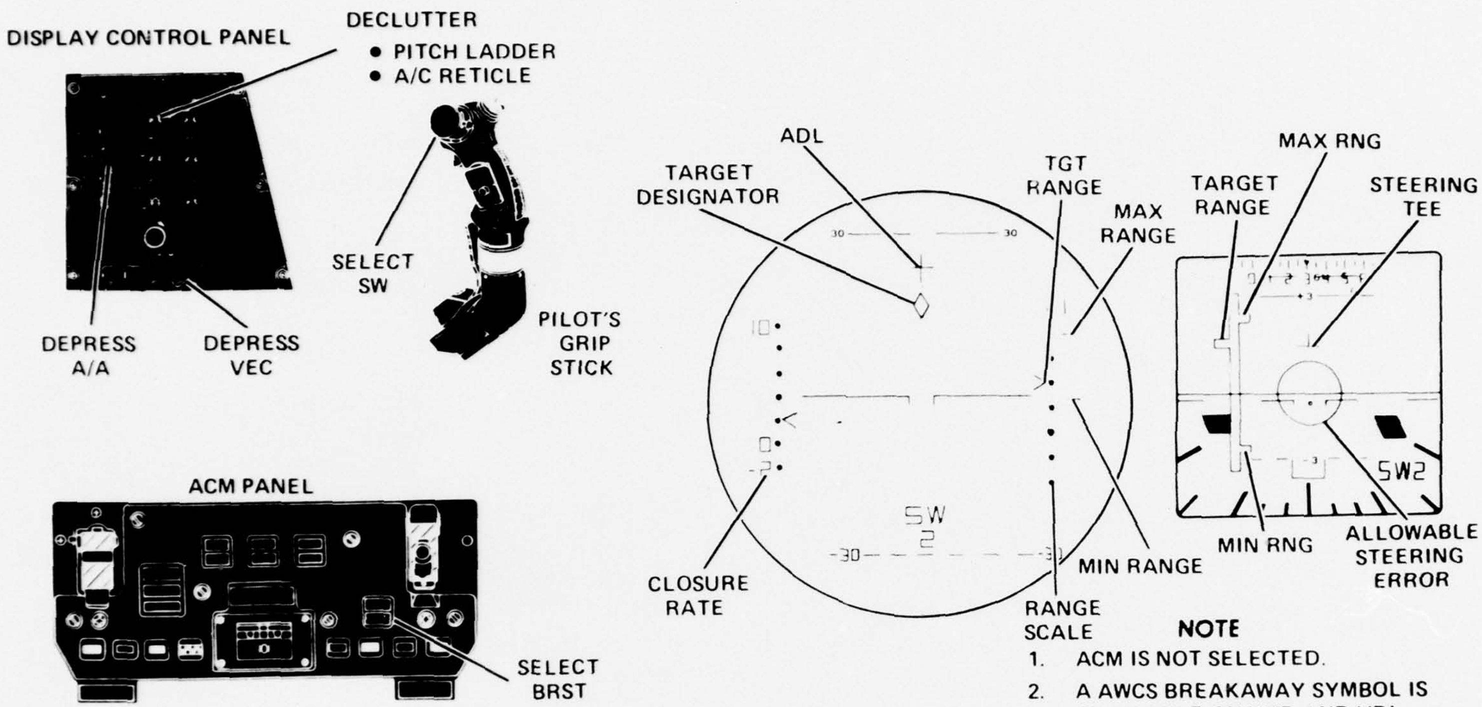
Figure 8. Air-To-Air Manual Gun Mode



NOTE

1. ACM NOT SELECTED
2. ON THE HUD, THE CLOSURE RATE SCALE, TARGET DESIGNATOR, AND THE RANGE SCALE ARE DISPLAYED ONLY FOR SLAVE/SEAM MISSILE MODES.
3. ON THE VDI, THE STEERING CROSS, AND RANGE SCALE ARE DISPLAYED ONLY FOR SLAVE/SEAM MISSILE MODES
4. D/L COMMAND CAN BE DISPLAYED IN THIS MODE

Figure 9. Air-To-Air Sidewinder Normal Mode



NOTE

1. ACM IS NOT SELECTED.
2. A AWCS BREAKAWAY SYMBOL IS AVAILABLE ON HUD AND VDI.
3. D/L COMMANDS CAN BE DISPLAYED IN THIS MODE.

Figure 10. Air-To-Air Sidewinder Boresight Mode

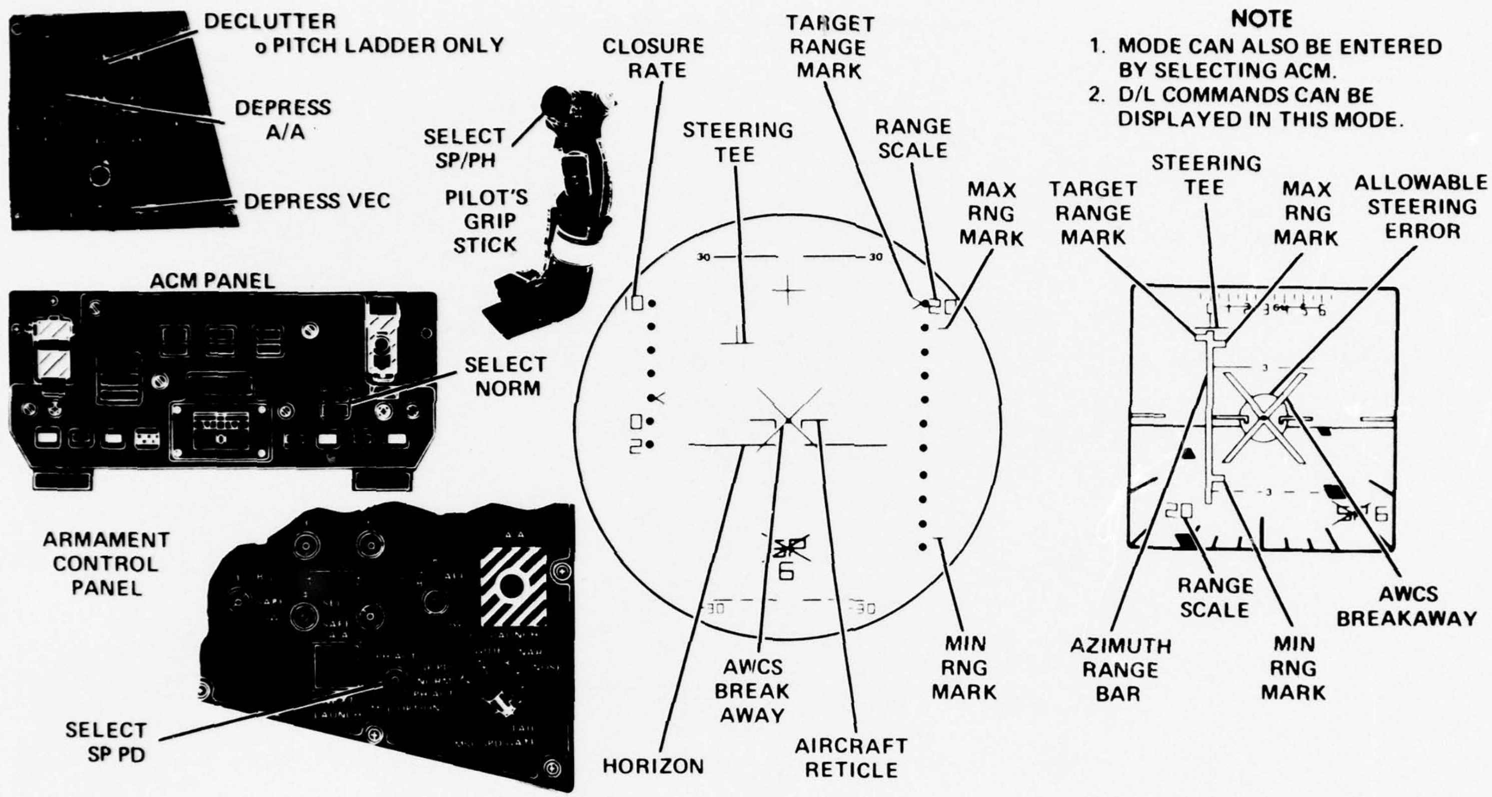
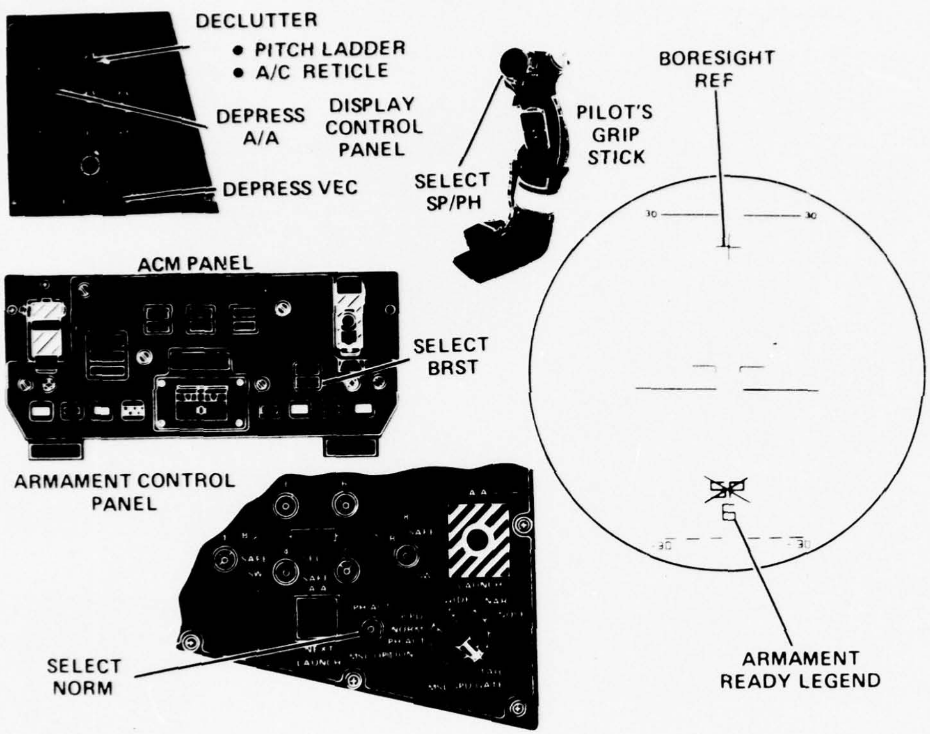


Figure 11. Air-To-Air Sparrow Normal Mode



NOTE

1. MODE CAN ALSO BE ENTERED WITH THE SELECTION OF ACM
2. D/L COMMANDS CAN BE DISPLAYED IN THIS MODE

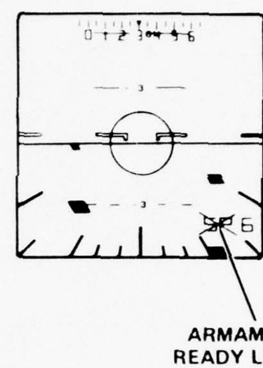


Figure 12. Air-To-Air Sparrow Boresight Mode

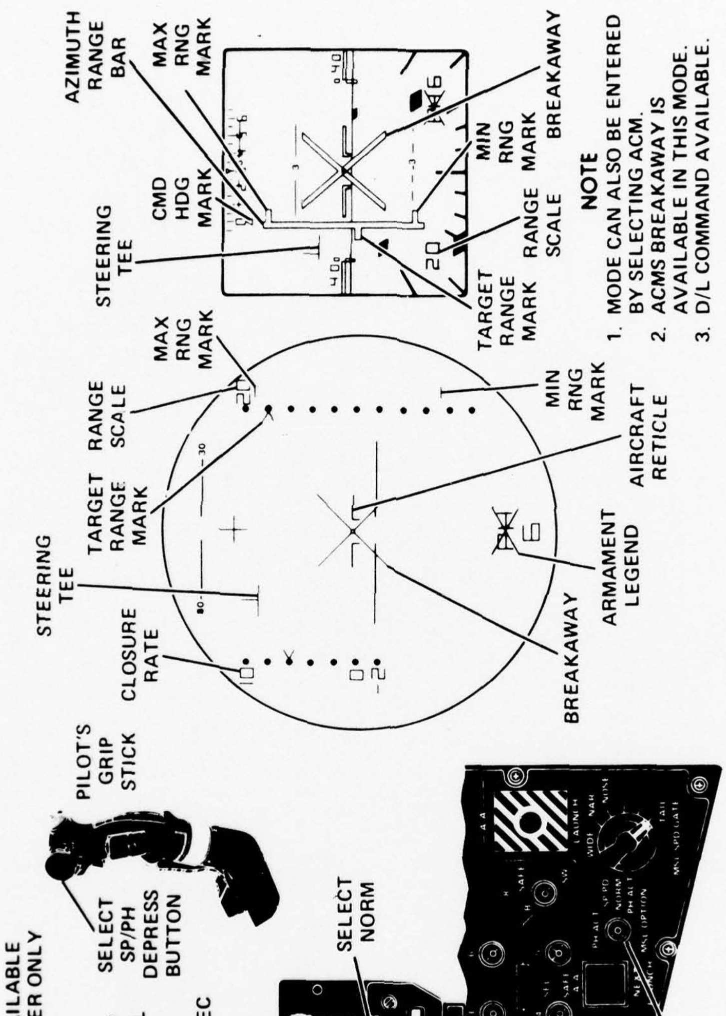


Figure 13. Air-To-Air Phoenix Normal Mode

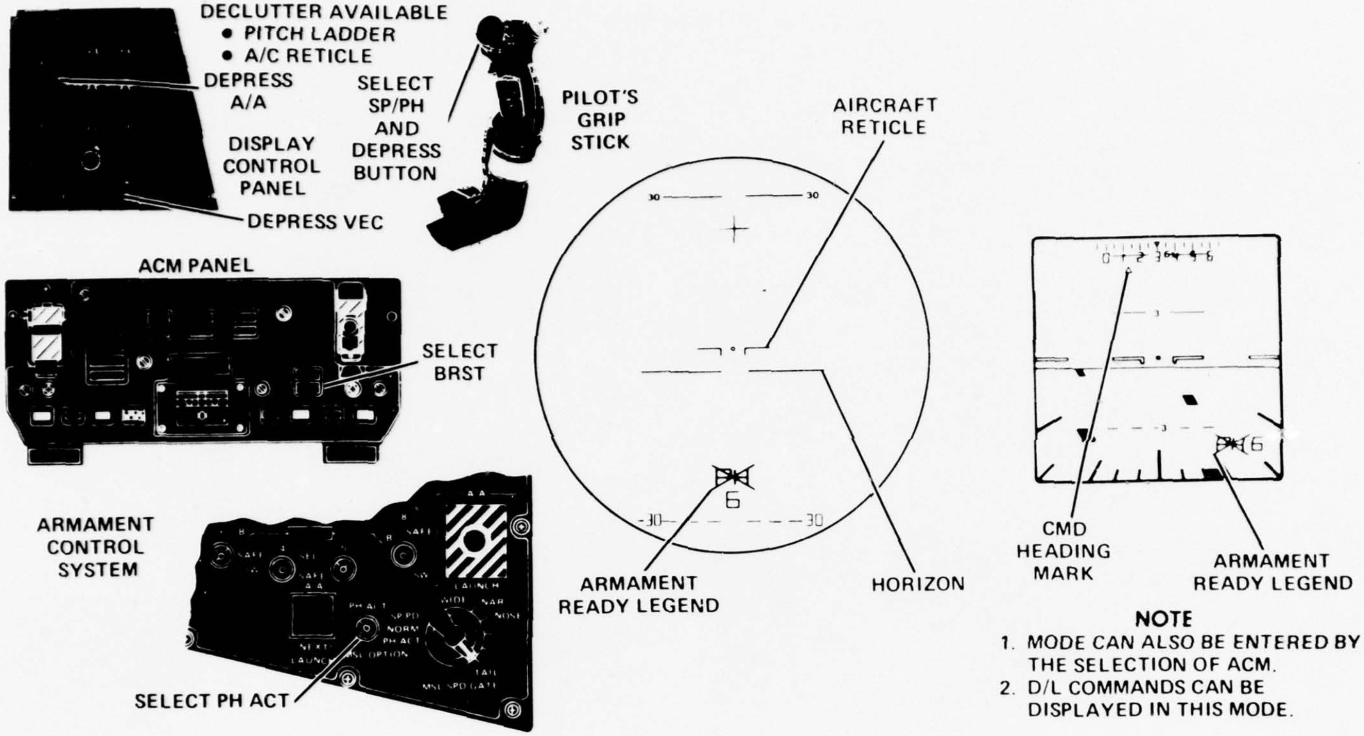


Figure 14. Air-To-Air Phoenix Boresight Mode

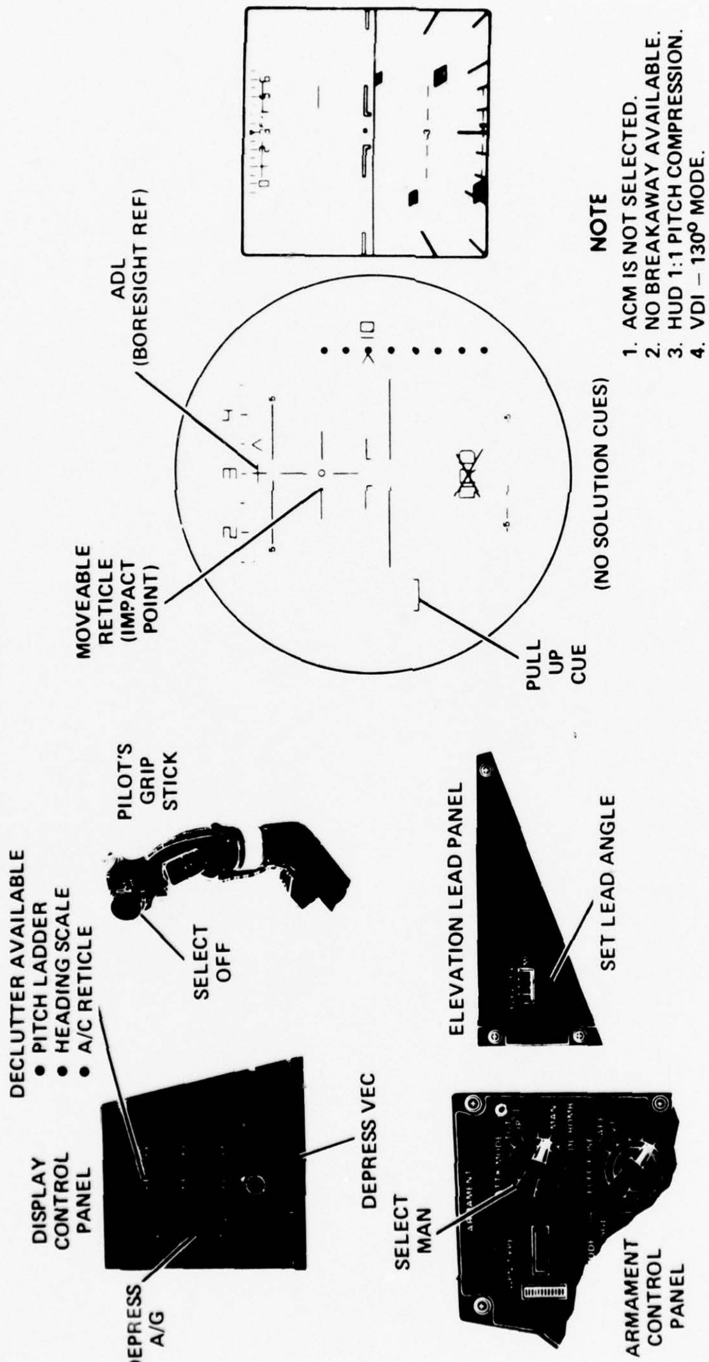
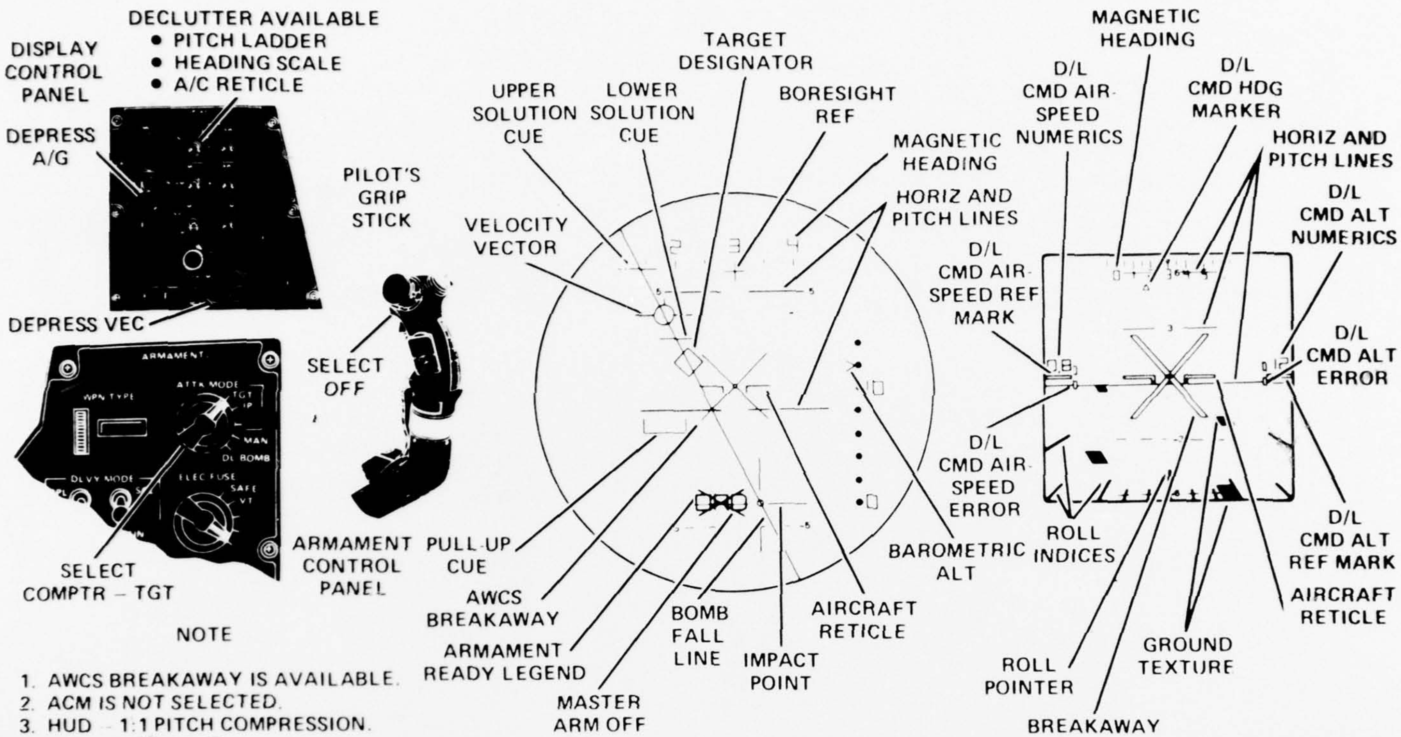


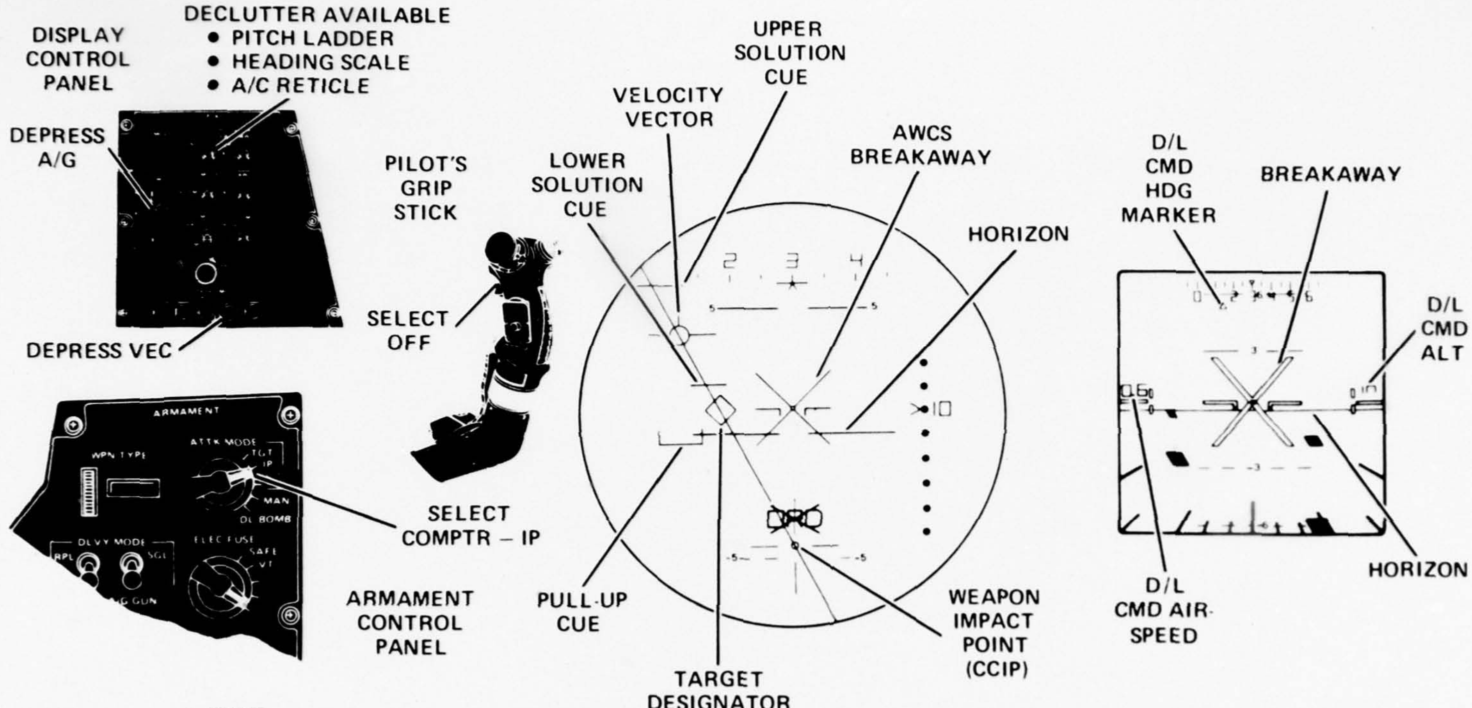
Figure 15. Air-To-Ground Manual Mode



NOTE

1. AWCS BREAKAWAY IS AVAILABLE.
2. ACM IS NOT SELECTED.
3. HUD – 1:1 PITCH COMPRESSION.
4. VDI – 130° MODE.

Figure 16. Air-To-Ground Computer-Target Mode



NOTE

1. AWCS BREAKAWAY IS AVAILABLE.
2. ACM IS NOT SELECTED.

Figure 17. Air-To-Ground Computer-IP Mode

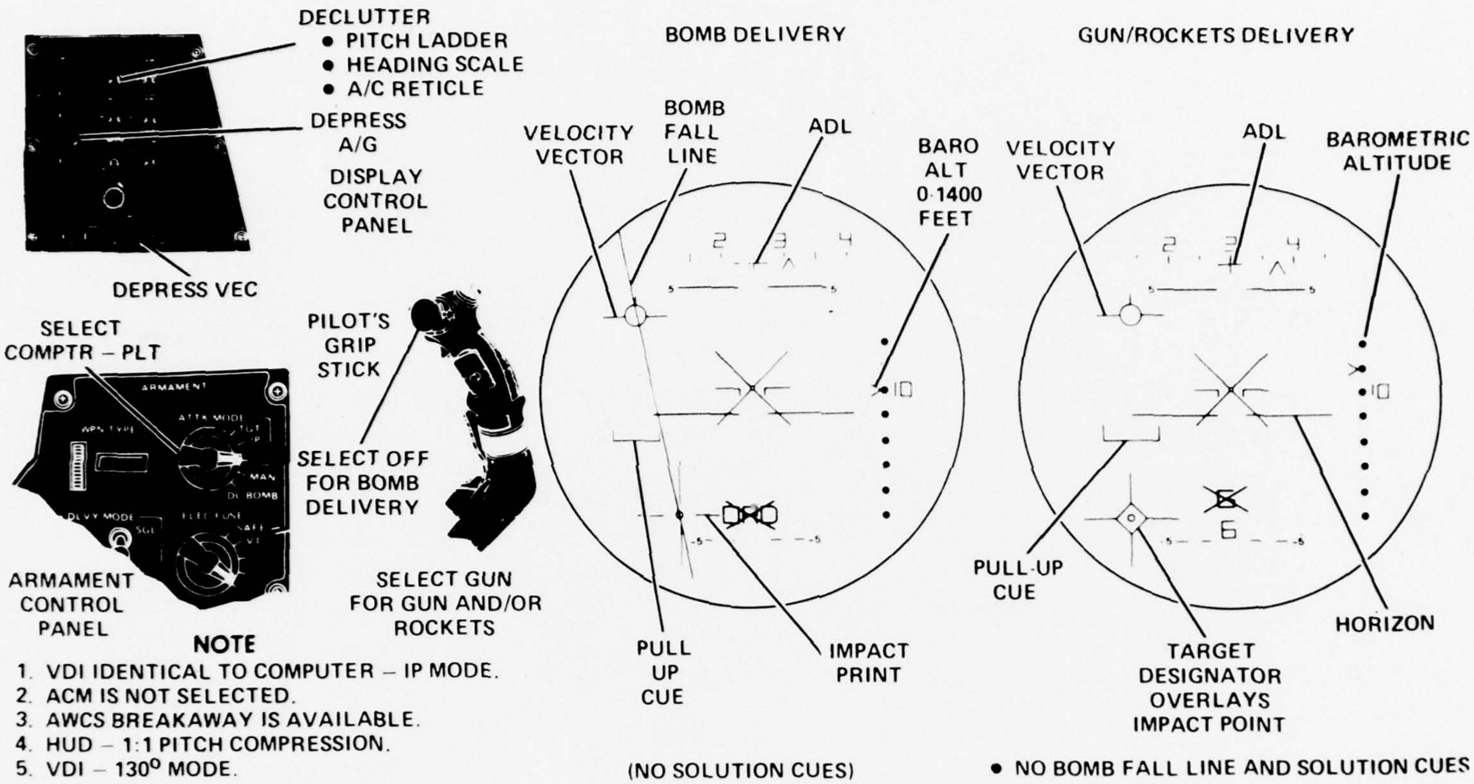
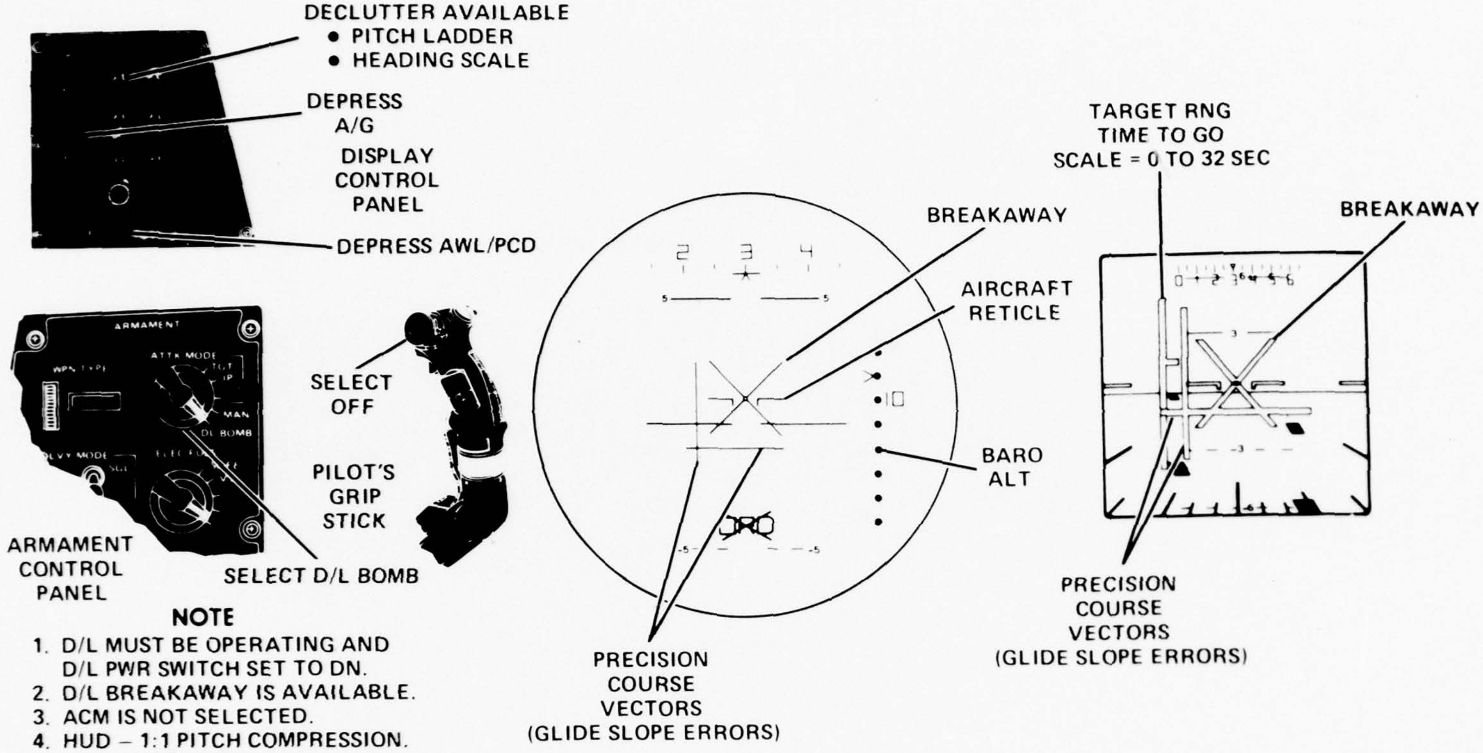


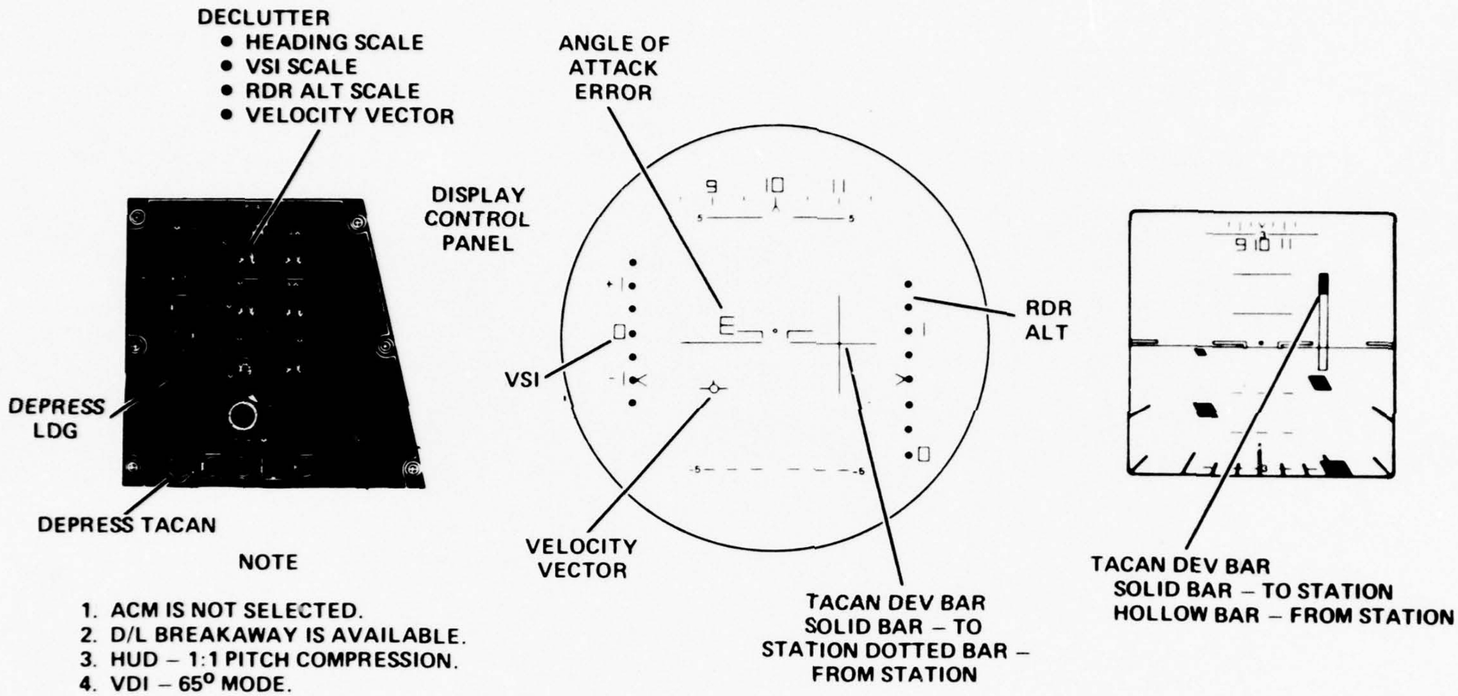
Figure 18. Air-To-Ground Computer-Pilot Mode



NOTE

1. D/L MUST BE OPERATING AND D/L PWR SWITCH SET TO DN.
2. D/L BREAKAWAY IS AVAILABLE.
3. ACM IS NOT SELECTED.
4. HUD – 1:1 PITCH COMPRESSION.
5. VDI – 130° MODE.

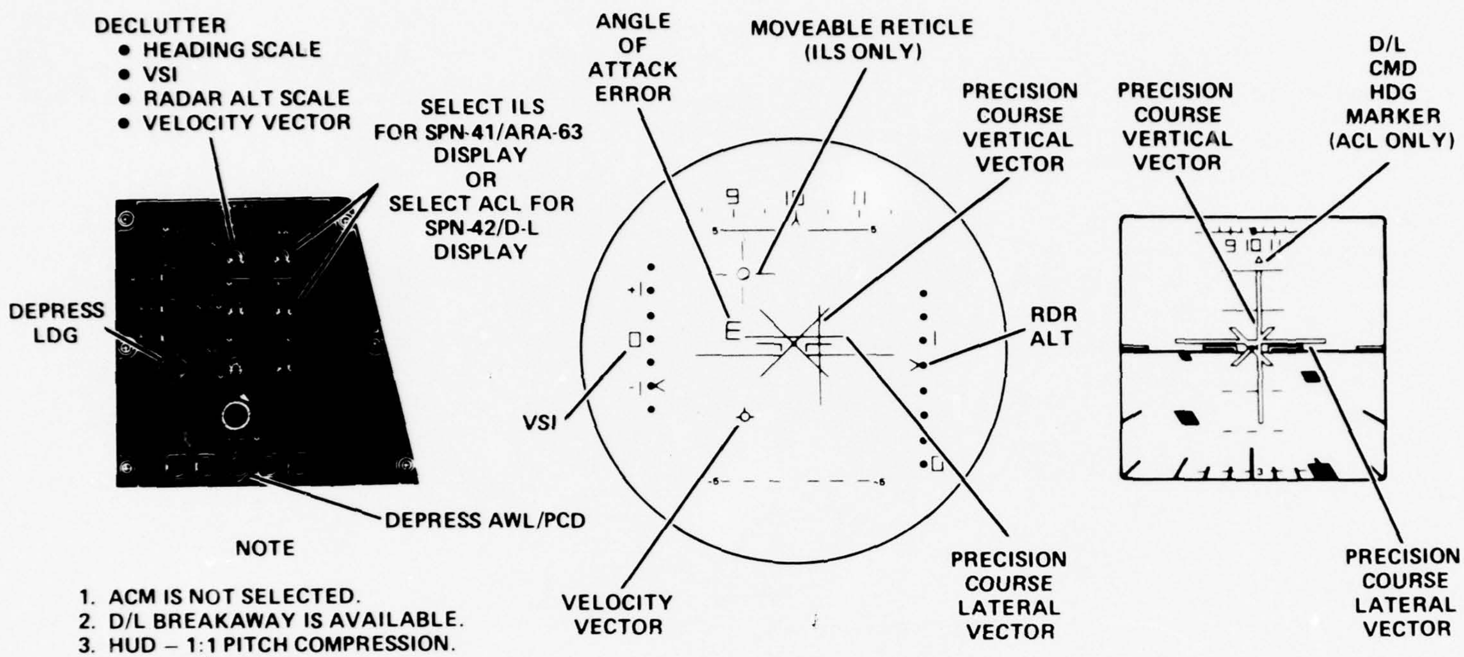
Figure 19. Air-To-Ground PCD Mode



NOTE

1. ACM IS NOT SELECTED.
2. D/L BREAKAWAY IS AVAILABLE.
3. HUD – 1:1 PITCH COMPRESSION.
4. VDI – 65° MODE.

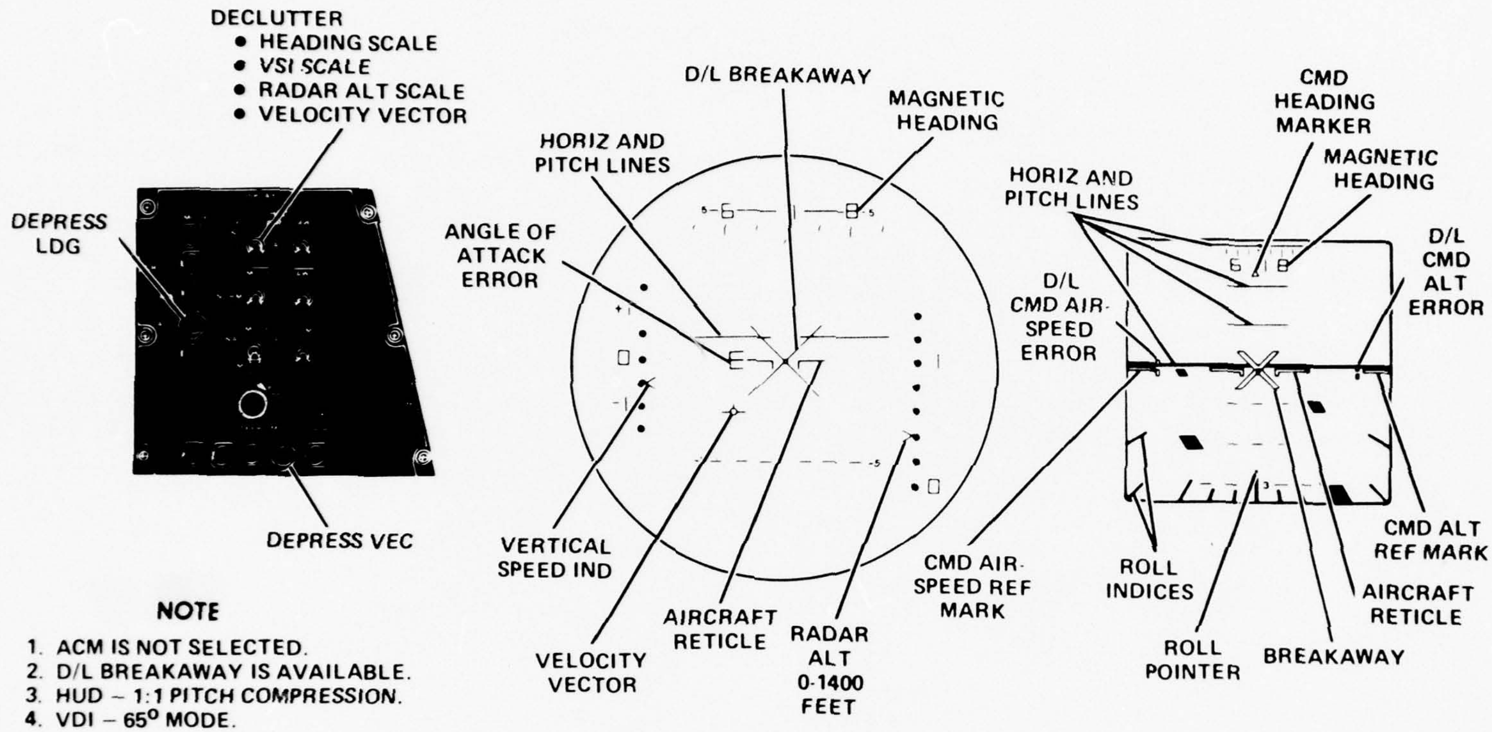
Figure 20. Landing Mode/TACAN Submode



NOTE

1. ACM IS NOT SELECTED.
2. D/L BREAKAWAY IS AVAILABLE.
3. HUD – 1:1 PITCH COMPRESSION.
4. VDI – 65° MODE.

Figure 21. Landing Mode/AWL Submode



NOTE

1. ACM IS NOT SELECTED.
2. D/L BREAKAWAY IS AVAILABLE.
3. HUD – 1:1 PITCH COMPRESSION.
4. VDI – 65° MODE.

Figure 22. **Landing Mode/Vector Submode**

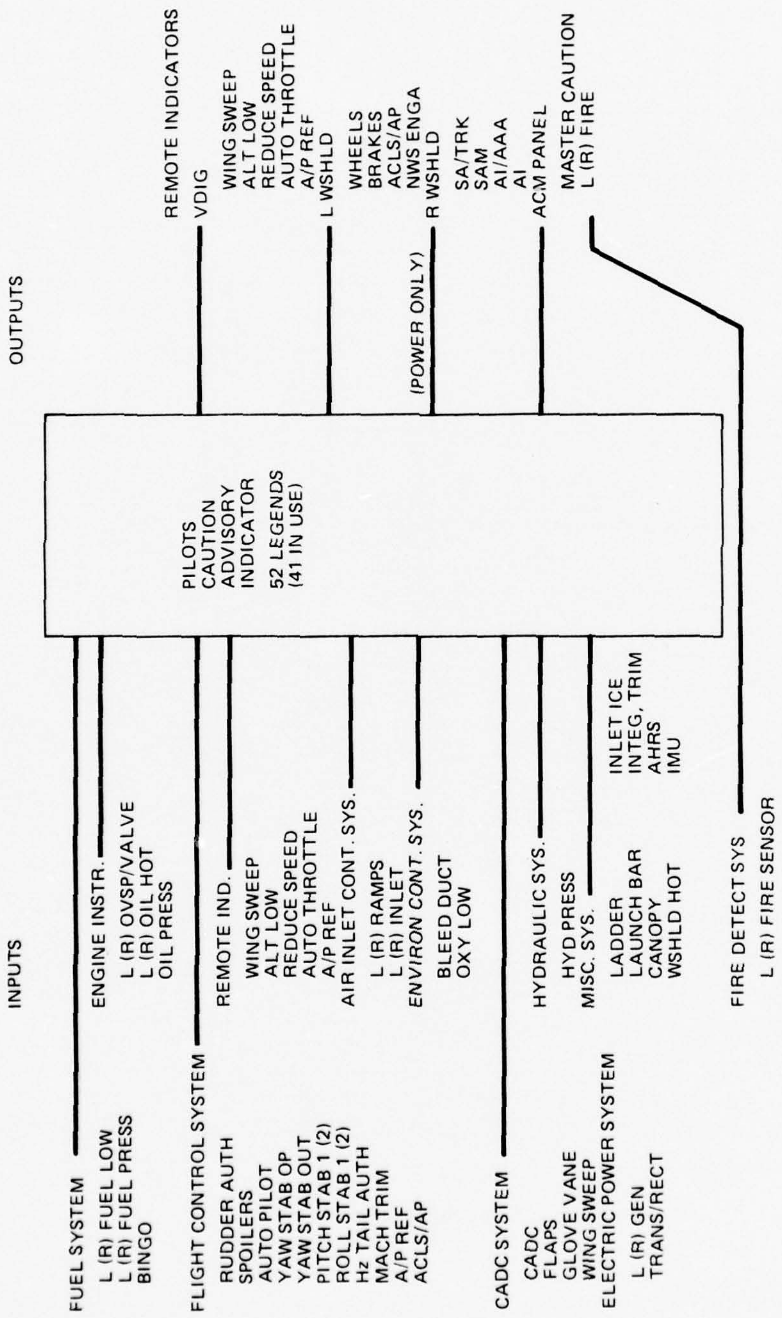


Figure 23. F-14 Sensor Block Diagram

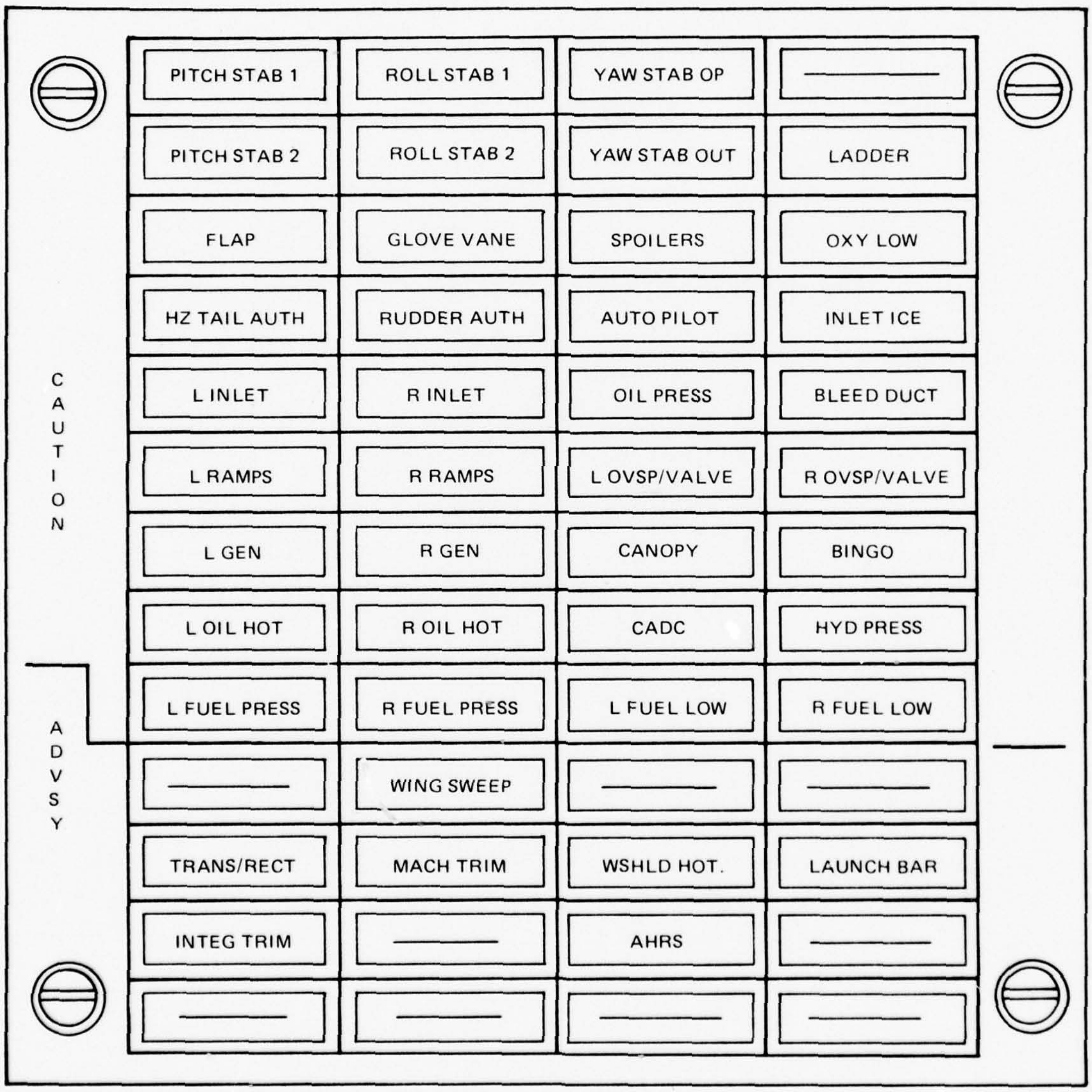


Figure 24. F-14 Caution Advisory Indicator

TASK 2

Task 2 includes the following:

- Matrix - Table 3 is a matrix of MMD inputs vs outputs. The same table is included as part of the MMD specification.
- Analysis of F-14 signal data available to MMD
- Requirements to add course of action
- F-14 equipment deleted with addition of MMD
- Summary of weight, volume, and power deltas
- MMD design
- Recommended format for display of information
- Other uses of MMD
- Shopping list of complexity vs amount of information displayed.

The F-14 cockpit layout with the MMD is shown in Task 3 in Figures 39 and 40 as part of Implementation Problems.

TABLE 3. MMD INPUTS VS OUTPUTS

MMD Outputs \ MMD Inputs	ACLS/AP	AHRS	Auto Pilot	Auto Throttle	Brakes	A/P Ref	Bingo	Bleed Duct	CADC	Canopy	L(R) Fire
Inactive	OC	OC	4.5 vdc	OC	OC	4.5 vdc	OC	OC	Sat. Trans Cutoff Trans	OC	OC
Active	Gnd	Gnd A/C	O vdc	Gnd	26 vdc	OC	28 vdc	28 vdc		28 vdc	28 vdc
Remote Warning Indication					X						X
Master Caution	X	X	X	X		X	X	X	X	X	
ACLS/AP Disengaged	X										
1. Take Control - Land Manually											
AHRS/Compass Controller Failure		X									
1. Use INS-IMU											
2. Avoid IFR Flt if INS-IMU not Avail.											
Auto Pilot Failure			X								
1. Check A/P Mode Failure											
2. Recycle A/P Engage											
Auto Throttle Disengaged				X							
1. Assume Manual/Boost Control											
2. Satisfy APC Interlocks											
3. Reengage APC Auto											
Brakes					X						
1. Anti Skid - Off											
2. Caution-Modulate Brakes											
3. Release Emergency Brake											
A/P Ref Not Engaged						X					
1. Depress Ref Engage Button											
Bingo							X				
1. Fuel Remaining is Reqd to Return to Base											
Bleed Duct								X			
1. Air Source - Off											
2. Ram Air-Increase (< 300 KIAS/0.8 IMN)											
3. Land-ASAP											
CADC Failure									X		
1. Master Reset-Depress – If Fault Remains											
2. Remain Below 1.5 IMN											
Canopy Unlocked										X	
1. Canopy Handle-Boost Close											
2. Visors/Seats-Down											
3. Stay Below 200 KIAS/15,000 Ft											
4. Land ASAP											
L(R) Fire											X
1. Throttle Affected Engine - Idle											
2. Air Source - Off											
3. If Fault Goes Away-Check Fire Det Sys If Fault Remains or Fails Fire Det Test:											
4. Throttle Affected Engine-Off											
5. Fuel Shutoff Affected Engine/Pull											
6. Land ASAP											
7. If Fire Persists - Eject											

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	L Fuel Low	R Fuel Low	L Fuel Press.	R Fuel Press.	L Gen	R Gen	Glove Vane	Oxy Low	Hz Tail Auth
Inactive	OC	OC	OC	OC	OC	OC	Sat. Trans	OC	4.5 vdc
Active	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	Cutoff Trans	28 vdc	0 vdc
Remote Warning Indication	X	X	X	X	X	X	X	X	X
Master Caution									
L(R) Fuel Low	X	X							
1. Dump Switch-off									
2. Fuel Distribution-Check-Balance									
If Wing/Ext Fuel Remains:									
3. Wing/Ext Trans Switch-Oride									
L (R) Fuel Press.			X	X					
1. No A/B Above 15,000 Ft on Affected Engine									
2. Fuel Distribution-Monitor/Balance									
3. Land ASAP									
If BothL&R Faults Occur									
1. Descend to < 25,000 Ft									
2. Maintain Cruise Power or Less									
3. Land ASAP									
L (R) Gen Off Line					X	X			
1. Affected Gen-Off/Reset, Then Norm									
If Fault Remains:									
2. Affected Gen-Test									
Fault Goes Away-Distr Sys Problem									
Fault Remains-IDG/GCU Problem									
If Both L&R Gen Faults Occur									
1. Generators - Cycle									
If Temp Loss of Comb Press. Causes Emerg Gen to Drop Buss 2									
2. Emerg Gen-Cycle									
3. Land ASAP									
Glove Vane							X		
1. Check Hyd Pressure									
2. Maneuver Devices-Retract									
3. Master Reset-Depress									
Oxygen Low								X	
1. Cabin Alt < 10,000 Ft									
2. Mask-Off									
3. Oxy Switch - Off									
4. Oxy and Mask on For Landing									
HZ Tail Auth									X
1. Master Reset-Depress (10 Sec)									
2. > 400 KIAS, Restrict Lateral Control to ¼ Throw									
3. No Oversweep on Deck									

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	Reduce Speed	Roll Stab. 1	Roll Stab. 2	Pitch Stab. 1	Pitch Stab. 2	Rudder Auth	Spoilers	Trans/Rect	Wheels
Inactive (Sat. Trans)		4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	OC	OC
Active (Cutoff Trans)		0 vdc	0 vdc	0 vdc	0 vdc	0 vdc	0 vdc	28 vdc	28 vdc
Remote Warning Indication	X								X
Master Caution		X	X	X	X	X	X	X	
MMD Fault & Course of Action									
Reduce Speed	X								
1. Decel to < 280 KIAS									
2. *Check Flap Handle - 0°*									
3. Master Reset - Depress - Then Repeat Cmd									
Roll/Pitch Stab. 1 or 2 Failure		X	X	X	X				
1. Cycle Appropriate Stab. Aug Sw									
No Corr Action or Limitations									
If Both 1 & 2 Roll/Pitch Stab. Faults Occur									
1. Airspeed - Decel to Stab. Limits									
Pitch - Not Restricted									
Roll - 0.93 IMN									
2. Wait 10 Sec for Self Test									
3. Recheck Faults									
If One Fault (1 or 2) Goes Away - Reset Stab Aug - No Limits									
If Both Faults (1 & 2) Remain,									
1. Leave Stab. Aug. - Off									
2. Stay Below Stab. Limits									
Warning: Do Not Engage ACLS or DLC									
Rudder Auth						X			
1. Reduce Airspeed - Use Caution in Rudder Deflection While at High Airspeed									
2. Master Reset - Depress 10 Sec									
3. If Fault Remains, Limit Rudder Above 250 KIAS to < 10°									
4. Landing - Possible Limited Rudder & NWS									
Spoilers							X		
1. Neutralize Lateral Control									
2. Master Reset - Depress									
If Fault Remains									
3. Avoide Abrupt Lateral Control & High Roll Rates									
Warning: With Wings Forward of 57°, Excessive Horiz Tail Differential May Cause Severe Structural Damage									
Trans/Rect Failure								X	
No Crew Action									
Wheels Not Down									X
Lower Landing Gear									

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Outputs \ MMD Inputs	Integ Trim	L Inlet	R Inlet	INlet Ice	Ladder	Launch Bar	Mach Trim	Nav Comp	NWS Engaged	L Ramp	R Ramp
Inactive	OC	OC	OC	OC	OC	OC	4.5 vdc	OC	OC	OC	OC
Active	Gnd A C	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	0 vdc	Gnd A C	Gnd	28 vdc	28 vdc
Remote Warning Indication											
Master Caution	X	X	X	X	X	X	X	X	X	X	X
MMD Fault & Course of Action											
Integ Trim Failure - Use Manual Trim	X										
L (R) Inlet &/or L(R) Ramp		X	X							X	X
1. Decel to < 0.9 IMN											
2. Avoid Abrupt Throttle Movements											
3. Stow Affected Ramp											
4. *Inlet Ramp Auto*											
If Ramp Fault Remains											
5. Check for Hyd Failure											
Note: Ramp Blow Back is Enhanced by Mil Power at 200 KIAS (Ramp 1) & by Idle at 0.85 IMN (Ramp 3) With Inlet Switch in Auto											
6. *Throttle (Bad Engine)* 80% *or Less*											
7. Land ASAP											
If ATTEMPTING AICS RESET (Inlet Fault Only)											
8. Decel to < 0.5 IMN											
9. Affected Ramp Stow											
10. Affected AICS CB Cycle (LF2 or LG2)											
Warning: If Caution Wing Sweep Fault is Present, Cycling Right AICS CB May Cause Wings to Sweep											
11. Inlet Ramp Auto											
12. If Inlet Fault Remains, Stay < 0.9 IMN											
Inlet Ice				X							
1. Anti Ice Switch - Oride											
2. When Clear of Icing Cond, Select Auto											
Ladder Unlatched					X						
1. Airspeed Minimum											
2. Airborne Visible Inspection if Feasible											
3. Land ASAP											
Launch Bar						X					
On Ground Take Appropriate Action											
In Flight Do Not Retract Landing Gear											
Land ASAP											
Mach Trim							X				
1. Master Reset Depress											
2. *Use Manual Trim*											
Nav Computer Failure								X			
1. Switch to IMU (NFO)											
NWS Engaged									X		
If NWS is Not Desired, Depress Button on Stick Grip to Disengage NWS											

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TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	LN1 OVSP	RN_1 OVSP	L St Valve	R St Valve	L Oil Hot	R Oil Hot	L Oil Press	R Oil Press	ARI
Inactive	OC	OC	OC	OC	OC	OC	OC	OC	OC
Active	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	Gnd A/C	Gnd A/C	28 vdc
Remote Warning Indication									
Master Caution	X	X	X	X	X	X	X	X	X
L (R) N_1OVSP	X	X							
1. Throt Affected Engine - Idle									
2. Nozzle Position - Check									
3. Avoid Hi Power Settings									
4. Land ASAP									
L (R) St Valve			X	X					
If Airborne									
1. Air Source - Off									
2. Eng Crank Sw - Off									
3. If Fault remains - Land ASAP									
4. If fault goes away, Air Source - Both									
5. Land ASAP									
Caution: With Air Source Off, Stay Below 300 KIAS/0.8 IMN									
If On Deck									
1. Air Source - Off									
2. Throt - Affected Engine - Off									
L (R) Oil Hot					X	X			
1. Throttle Affected Engine - As High Fuel Flow as Practical									
2. Induce Slight Left Sideslip (R Rudder)									
3. If Fault Remains After 1 Min, Throttle-Off									
4. Land ASAP									
5. Relight Engine for Ldg if Necessary									
L (R) Oil Press. Low (Affected Engine)							X	X	
1. Oil Press. 40 PSI at MIL, Throttle - Idle									
2. Oil Press. 35 PSI at Idle, or Engine Vibration, Throttle - Off									
3. If Shutdown Not Feasible, Set 78% RPM									
4. Avoid High G or Large Throttle Movements									
5. Land ASAP									
ARI Engaged									X
Disengage if Not Desired									

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	Wshld Hot	Yaw Stab. Op	Yaw Stab. Out	IMU	Cabin Press.
Inactive	OC	4.5 vdc	4.5 vdc	Gnd (A/C)	OC
Active	28 vdc	0 vdc	0 vdc	OC	28 vdc
Remote Warning Indication					
Master Caution	X	X	X	X	X
MMD Fault & Course of Action					
Windshield Hot	X				
1. Wshld Switch - Off					
2. Air Source - Off (Below 35,000 Ft) If Fault Remains After Air Source is Off, Indication is Faulty. Turn ECS on & Land ASAP					
3. Ram Air - INCR (< 300 KIAS/0.8 IMN)					
4. Land ASAP					
Yaw Stab. OP		X			
1. Master Reset - Depress					
2. If Fault Remains, Stay Below 0.93 IMN					
YAW STAB. OUT			X		
1. Yaw Stab. - Off					
2. Master Reset - Depress If Fault Goes Away - Reengage Yaw Stab. If Fault Remains - Stay Below 0.93 IMN					
IMU Failed (NFO)				X	
1. Switch to AHRS					
Cabin Press. (NFO)					X
1. Oxy Mask - ON					
2. Cycle Press. Switch					

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs →	Flt Hyd Press.	Comb Hyd Press.
Inactive	OC	OC
Active	28 vdc	28 vdc

MMD Outputs	Flt Hyd Press.	Comb Hyd Press.
Remote Warning Indication		
Master Caution	X	X
Flt Hyd Press. Low	X	
If Approx 2100 PSI		
1. Wing Sweep – 20°		
2. Right Ramp (< 0.9 IMN) - Stow		
3. Emerg Flt Hyd - High (Just Prior to Dirty-Up)		
Equip Inop: Normal Hook - Restored by WOW		
4. Land ASAP		
Note: Arrested Landing Requires Emerg Hook Ext		
If Approx 0 PSI		
1. Bi-Direct Pump - OFF		
2. Wing Sweep - 20°		
3. Emerg Flt Hyd Sw - High (Just Prior to Dirty-Up)		
4. Equip Inop: R Glove Vane, ACLS, R AICS, and Norm Hook (Restored by WOW)		
5. Land ASAP		
NOTE: Arrested Ldg Requires Emerg Hook Ext		
Comb Hyd Press. Low		
If Approx 2100 PSI		
1. Hyd Isol - Flt		X
NOTE: Monitor Aux Brks Gage, Tap Wheel Brake to Seat Priority Valve if Press. is Decreasing		
2. Wing Sweep - 20°		
3. Left Ramp (< 0.9 IMN) - Stow		
4. Equipt Inop - None		
5. Emerg Flt Hyd - High (Just Prior to Dirty-Up)		
6. Land ASAP		
If Approx 0 PSI		
1. Bi-Direct Pump - Off		
2. Wing Sw - 20°		
3. Equip Inop: L AICS, L Glove Vane, Emerg Gen, Aux Flaps, Inbd Spoilers, NWS, Gun Drive, DLC, Spd Brks, Norm Hook, Hook Extend*, Flaps/Slats*, Ldg Gear*, Wheel Brakes*, Refuel Probe*		
* Emerg Actuation Available		
4. Emerg Flt Hyd - High (Just Prior to Dirty-Up)		
5. Wheels - Emerg DN		
6. Flaps/Slats - DN (No Aux Flap)		
7. Hook - Emerg DN		
8. Brake Hand Pump - Check		
9. Anti Skid/Spoiler Bk - Spoiler Bk (Off for CVA)		
10. Arrest Land ASAP		
After Landing:		
11. Engines - Off		
Stay in Arresting Gear		

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

Flaps Sat. Trans (Inactive) Cutoff Trans (Active)	MMD Inputs / MMD Outputs
	Remote Warning Indication
X	**Master Caution**
	MMD Fault & Course of Action
X	**Flap/Slat Malfunction**
	After Raising Handle-Flaps/Slats Not Indicating Up
	1. Remain below 225 KIAS
	2. Master Reset-Depress
	3. Maneuver Flap Thumbwheel-Full Forward
	If Fault Remains
	4. FLAP Handle-Emerg Up
	After Raising Flap Handle-Flaps/Slats Indicate Up
	1. Remain Below 225 KIAS
	2. Master Reset-Depress
	3. Maneuver Flap Thumbwheel-Full Forward
	If Fault Remains:
	4. Flaps-Cycle
	If Flaps Respond:
	5. Master Reset-Depress
	If Fault Remains:
	6. Attempt to Sweep Wings to 25° (Manual Mode).
	If Wings Will Not Sweep Aft of 20, Both Aux Flaps are not Retracted & Limit Switches Are Not Made:
	7. Remain Below 0.7 IMN (Maneuver Flaps & Auto Retract May be Inoperative)
	If Wings Will Sweep Aft of 20°:
	8. Accelerate to 300 KIAS.
	9. Attempt Wing Sweep Aft of 50° (Manual Mode).
	If Wings Will Not Sweep Aft of 50°, Main Flaps Are Not Fully Retracted:
	10. FLAP Handle-Emerg Up
	11. *Reattempt to Sweep Wings Aft of 50*
	If Wings Still Will Not Sweep Aft of 50°:
	12. Remain Below 0.8 IMN.
	Note If wings sweep aft of 50°, aircraft flight envelope is unrestricted. Maneuver flaps & auto retract may be inoperative.
	After Lowering Flap Handle-Flap/Slats Not Indicated Down:
	1. FLAP Handle-Emerg Down
	After Lowering Flap Handle-Flap/Slat Indicating Down:
	1. Wing Sweep-Check at 20° (Allow 10 Sec for Auxiliary Flaps to Extend)
	2. Master Reset-Depress

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

FLAPS (Cont'd) Asymmetry Flap/Slap Lockout Inactive: Sat. Trans OC Active: Cutoff Trans. 28 vdc		MMD Inputs / MMD Outputs
		Remote Warning Indication
X	X	**Master Caution**
		MMD Fault & Course of Action
	X	***Flap/Slat Malfunction***
		If Fault Remains: 3. Normal Landing Note Flap light may be caused by failure of auxiliary flaps to extend, increasing approach speed approximately 5 knots After Using Maneuvering Devices 1. Master Reset - Depress 2. Maneuvering Flap Thumbwheel - Full Forward If FLAP Fault Remains: 3. FLAP Handle - Emerg Up If Flaps Indicate Up: 4. Wing Sweep - Aft of 50° (manual mode) If Wings Will Not Sweep Aft of 50° 5. Remain Below 0.8 IMN Note If wings will sweep aft of 50°, aircraft flight envelope is unrestricted. Maneuver flaps and auto retract will be inoperative.
X		**ASYMMETRY FLAP/SLAT LOCKOUT**
		Warning Asymmetric flap extension can produce an uncontrollable rolling moment. The following procedures defeat the designed asymmetry protection and therefore should be used when a shipboard landing is the only alternative and flap extension is required to remain within arresting gear limits. 1. Airspeed - Maintain Less Than 225 KIAS 2. Maintain Wings - Level Flight 3. Aux Flap/Flap Çontr CB - NFO PUll (7G3) Warning Failure to pull the AUX FLAP/FLAP CONTR cb before completing the following steps may result in an uncontrollable pitch trim change due to auxiliary flap extension or retraction. 4. Flap Handle - Corresponding to Indicator Caution Placing the FLAP handle in either the full extend or retract position may result in damage because the overtravel switch will be disabled.

TABLE 3. MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	Asymmetry Flap/Slat Lockout (Cont'd) (Inactive: OC; Active: 28 vdc)	Wing Sweep (Inactive: A/C Gnd; Active: OC)	Wing Sweep (1) (Inactive: Sat. Trans; Active: Cutoff Trans)	Wing Sweep (2) (Inactive: A/C Gnd; Active: OC)
Remote Warning Indication			X	X
Master Caution	X	X		
MMD Fault & Course of Action				
Asymmetry Flap/Slap Lockout (Cont'd)	X			
5. Flap/Slat Contr Shutoff CB - Cycle (RE2)				
6. Slowly Move Flap Handle Toward Desired Position				
If Flaps/Slats Respond, Nuisance Lockout Has Been Eliminated				
7. Aux Flap/Flap Contr CB - NFO Reset (7G3)				
8. Master Reset - Depress				
If Flaps/Slats Do Not Respond:				
7. Reposition Flap Handle to Match Indicator				
8. Flap/Slat Contr Shutoff CB - Pull (RE2)				
9. *Slowly Move Flap Handle Toward Desired Position*				
If Aircraft Rolls:				
10. Move Flap/Slats Back to Where No Rolling Exists				
If Aircraft Does Not Roll:				
10. Stop Flap/Slat Travel Before Reaching Full Up or Full Down				
Caution				
With the Flap/Slat Contr Shutoff CB Pulled.				
No Overtravel Protection for the Flap/Slats Exists				
11. Flap/Slat Contr Shutoff CB - Reset (RE2)				
12. *Land Utilizing 15 Units AOA*				
Wing Sweep		X		
1. Master Reset - Depress				
2. If Fault Remains, One Channel Has Failed				
Wing Sweep - Both Ch Failed			X	X
No Auto/Man. Control				
1. Airspeed - Decel to < 0.9 IMN				
2. Check Spider Detent Engaged				
3. Master Reset - Depress				
Wait 15 Sec - If Warn Indication Remains				
4. Wing Sweep CB (2) - Pull (Wg Sw Drive No. 1 & 2, LE1, LE2)				
5. *Emerg Wing Sweep Handle* - Comply With:				
< 0.4 IMN - 20°				
< 0.7 IMN - 25°				
< 0.8 IMN - 50°				
< 0.9 IMN - 60°				
> 0.9 IMN - 68°				
Caution - Avoid ACM & Aerobatics				
-Before Ldg Use Flap Overtravel Position				
To Insure Flaps Remain Fully Extended				

ANALYSIS OF F-14 SIGNAL DATA AVAILABLE TO MMD

The F-14 CAI sensor signals are discrete and, as such, indicate go/no go conditions. Existing signals do not lend themselves to MMD type readouts where quantitative information is desired in addition to go/no go information. For example, the OIL PRESSURE indication is triggered ON if the oil pressure of either (or both) engine(s) goes below 25 psi. Present circuits do not indicate whether the low oil pressure condition is in the left, right, or both engines. In addition, the signal does not indicate the oil pressure level. This example is typical of certain types of present F-14 sensors used for the CAI. However, additional information is available to the pilot, in most cases, at the individual gauges where quantitative information is displayed. Table 4 lists some of the existing F-14 gauges and indicators, along with the implementation method. The signals derived and used to drive the gauges could also be used to provide quantitative information for the MMD. These signals would be processed and converted into digital words for the MMD. This could be accomplished through use of the multiplex technique described in Task 3. Go/no go conditions could also be determined from these quantitative signals by comparing the current operating values with stored tolerance values. This eliminates the need for the present discrete input signals for these parameters and then corresponding sensors could be removed. In Table 4, those parameters for which corresponding, independent, discrete signals are available to the MMD are shown with asterisks. Corresponding signals for the remaining parameters are not presently available to the MMD. In some cases the MMD will indicate a condition for which no quantitative value is required. For example, if an N_1 Overspeed (L, R) condition should occur, the MMD will furnish the sole indication of this condition to the pilot.

The majority of the existing sensor signals to the CAI, and those that will be available to an MMD indicate malfunctions for which there is no associated quantitative parameter. Typical of these are the flight control system sensors (Pitch Stab. 1, Roll Stab. 1, etc.) and the CADC systems (CADC, Glove Vane, Wing Sweep, etc.). In these cases, go/no go condition along with the course of action information displayed by the MMD appear to be adequate.

Due to the present status (advanced production) of the F-14 program, any aircraft modifications as described above would have a serious cost impact. The cost

TABLE 4. POTENTIAL SOURCES OF QUANTITATIVE INFORMATION

Existing Gauge/Meter	*Location*	*Method of Implementation*
Hydraulic Press.* (Comb & Flt)	L Knee Panel	Synchro System
Flaps	L Vert Console	Synchro System
Oil Press.* (L & R)	L Knee Panel	Var Reluctance Bridge & D'Arsonval
Tachometer (N_2) (L & R)	L Knee Panel	Gen, Freq. Counter
Total Inlet Temp (L & R)	L Knee Panel	Thermocouple
Fuel Flow (L & R)	L Knee Panel	Analog Voltage, 0-5VDC
Nozzle Position (L & R)	L Knee Panel	Synchro System
Wing Sweep	R Instr Panel	Analog Voltage, 0-10VDC

*For these, there are corresponding but independent, discrete, go/no go signals presently available to the MMD.

impact would result from the change itself, as well as the impact of the change on related activities and documents. This includes packaging and mounting of added circuits, modification to aircraft wiring, drawings, test plans and procedures, and technical manuals. In addition, qualification testing would be required for any new equipment.

Due to the expense of making aircraft changes, much effort has been expended toward proposing a practical MMD that requires minimum modification to the existing F-14 aircraft. Therefore, with few exceptions, this study proposes to use available inputs as they exist.

During the analysis of available signals, it was discovered that in several cases two sensor signals are combined into a single indication. This was done because of lack of spare indicator circuits in the CAI. For the MMD, we are recommending the separation of these signals, and the addition of several new signals. This will achieve more specific fault indication and course of action instruction. These signals are listed in Table 5, and the diagram of the wiring change is shown in Figures 25 and 26.

TABLE 5. PROPOSED MMD INPUT SIGNAL CHANGE

New Messages	*Old Messages*
L NI OVSP	L OVSP/Valve
L Start Valve	L OVSP/Valve
R NI OVSP	R OVSP/Valve
R Start Valve	L OVSP/Valve
Flt Hyd Press.	Hyd Press.
Comb Hyd Press.	L OVSP/Valve
R Oil Press.	Oil Press.
L Oil Press.	L OVSP/Valve
Asymmetry Flap/Slat Lockout	Did Not Exist
ARI Engaged	Did Not Exist

REQUIREMENTS TO ADD COURSE OF ACTION

The present CAI indicates faults or malfunctions in the F-14. With its inherent limitations, it performs this function very well. However, to know the proper action to take for the various faults, the pilot must refer to his pocket checklist. This is time consuming, and in some cases requires locating and reading several pages of procedure for a single fault. If several faults occur simultaneously, or in rapid succession, the workload would become overwhelming for the situation. Earlier in this report, the primary functions of an MMD were discussed and are summarized here:

1. Alert the pilot to conditions which require attention

2. Inform pilot of the required action to be taken for the alerted conditions.

With this goal in mind, it is felt that a practical MMD can be generated by expanding the existing CAI capability by making a few changes and adding course of action information to the display for each fault.

Adding course of action information creates the need for a memory (ROM), along with the necessary control and display provisions. The size of this memory is

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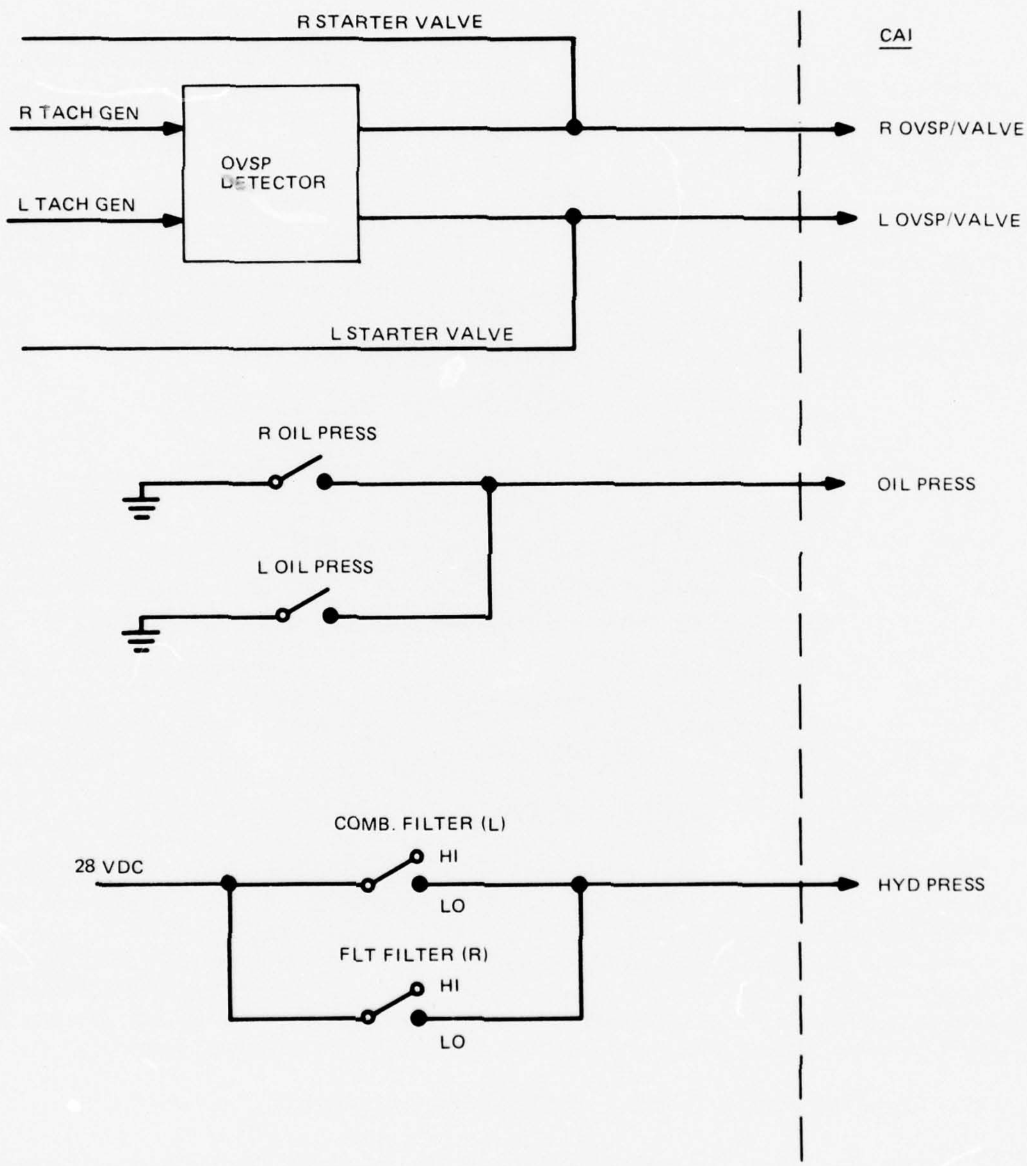


Figure 25. Present CAI Implementation

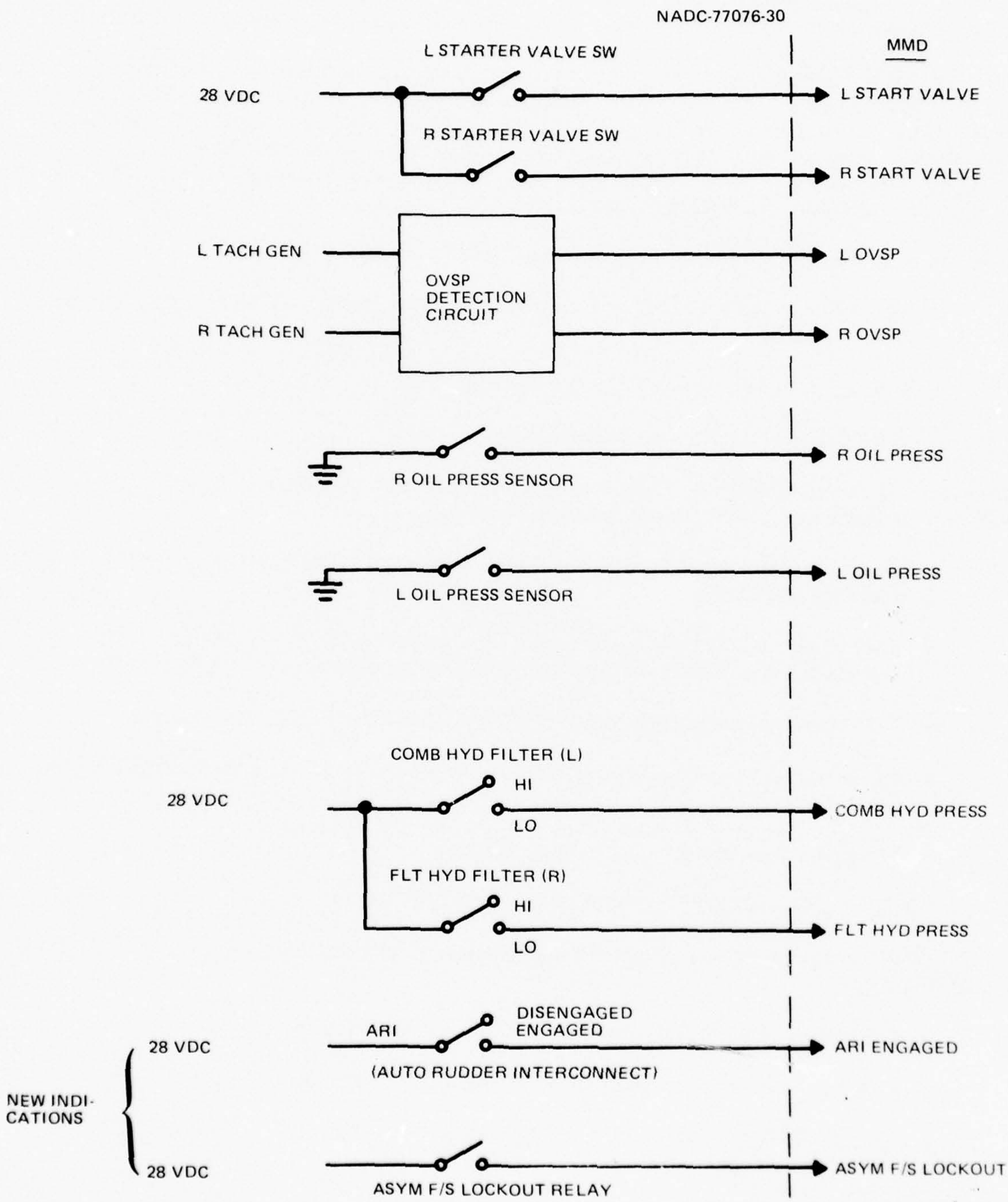


Figure 26. Proposed Implementation for MMD

determined by the total of all course of action information for each fault. In general, the course of action information is taken from the Pilots Pocket Checklist, NAVAIR 01-F14AAA-1B. Due to the amount of procedure to be stored in the ROM, a 120K bit storage capability is recommended. This includes a growth potential of about 20%.

Each input (fault) has an associated address. This address distinguishes a given input from all others. It also identifies a location in memory (ROM) where the associated block of course of action information is stored. If a fault condition is detected on an input, the corresponding course of action information is read into a RAM memory for display. This demonstrates the requirement for a RAM. The MMD RAM would accommodate the following functions:

- Storage for the continually updated status of each input
- Storage for the fault history feature. This portion will be non volatile for power shutoff
- Storage of control functions (programs, etc)
- Provide the display refresh function.

It is estimated that 10K bits RAM storage capability is required. A microprocessor, whose functions are listed below, is also required:

- Program the sampling and storage of status of each input during both normal and test conditions
- Locate the associated course of action information when a fault is detected, and direct the loading of this information into the RAM for display
- Program and format the information to meet display requirements
- Perform all required logic functions to meet the MMD operational requirements
- Program the display control functions.

F-14 EQUIPMENT DELETED WITH ADDITION OF MMD

In the front (pilot's) cockpit the candidate equipments for removal if an MMD is installed are:

• Caution Advisory Indicator	5.5 lb
• Wheels Warning Indicator and Mounting	0.5 lb
• Threat (DECM) Indicator and Mounting	0.5 lb
• Fire Warning Indicator (2)	0.2 lb

One of the main reasons for adding an MMD to the F-14 is to replace the various caution and warning indicators scattered about the cockpit with a centralized unit for displaying this information to the pilot. To ensure that in making such a change, capability is not lost, location of the new display is of prime importance. Ideally, it should be located within a 30° cone of vision (where the scattered indicators are located) described by a 15° angle rotated about a line from the design eye of the pilot to the top center of the instrument panel. The AIDS cockpit layout shown in Fig. 27 shows an attempt to achieve this location for the MMD. The reason for this location is to provide heads up acquisition of displayed information. Any deviation from this location sacrifices capability. In addition, some means of ensuring that messages do not go unnoticed is required, creating the need for a master caution indicator. After much consideration, it appears that the installation, which has the least impact on the cockpit, and in fact, appears to be the only practical location, is an enlargement of the area presently occupied by the CAI in the pilot's cockpit. This location has to some extent influenced the MMD design.

The suggested elimination of dedicated warning indicators particularly in the front cockpit, was met with considerable opposition from the Human Factors Group. The reason for this is that these indicators provide heads-up indication of warnings, which no practical location of the MMD in the F-14 cockpit can provide. This could be a crucial factor in combat or during carrier landings. Therefore, it is suggested that these indicators not be removed from the F-14 but left as they are if an MMD is installed. This means that the MMD would replace only the CAI in the front cockpit.

In the rear (NFO's) cockpit, the candidates for deletion with the addition of an MMD are:

1.	Caution Advisory Indicator (CAI)	2.6 lb
2.	Digital Data Indicator (DDI)	4.6 lb
3.	Threat (DECM) Indicator	0.8 lb

Incorporating functions of the rear cockpit CAI into an MMD does not in itself involve any significant problem. Finding a practical location for the MMD in the rear cockpit, however, is a major problem. Solutions to this problem are considered under Implementation Problems.

The DDI could be replaced by the MMD. However, there are certain features of the DDI which the MMD as presently conceived does not contain. These are:

- Certain types (Group 1) of messages can only be displayed one at a time, and remain until another of the same type cancels and replaces the old message.
- Other types (Group 2A, B, and C) can be displayed one of each sub-group at a time, however, they are self extinguishing after 30 seconds. Although the MMD could handle these messages as coded, no internal timing is presently provided. If the DDI was removed, the MMD would have to be modified to include the required display timing. This feature is only needed in the rear seat. The DDI is mission oriented while the MMD as proposed is aircraft

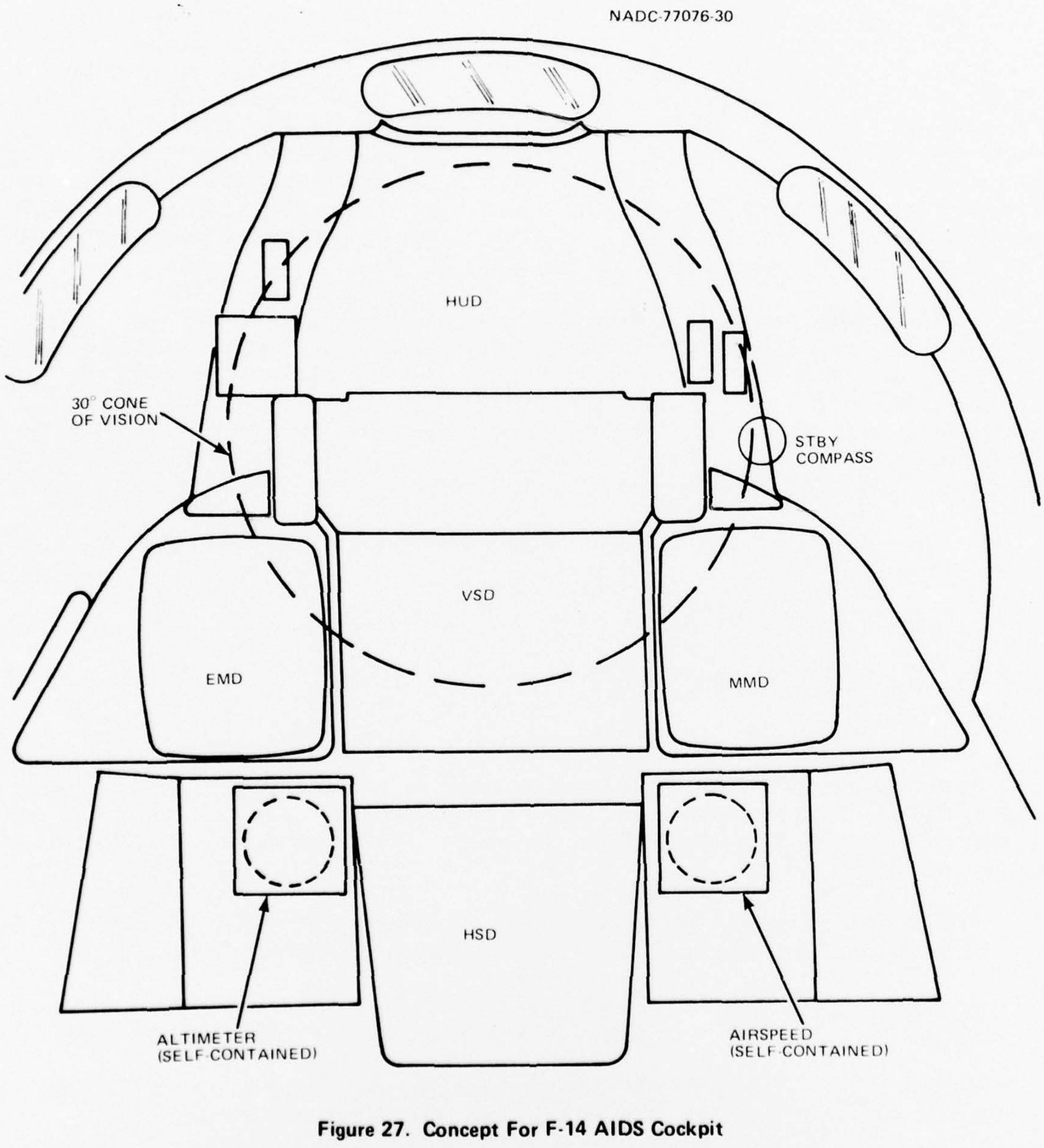


Figure 27. Concept For F-14 AIDS Cockpit

oriented. The issue of mission vs. aircraft orientation as related to the MMD should be investigated further. All 40 messages presently displayed on the DDI are advisory in nature.

The situation involving the Threat Indicator in the rear is similar to that in the front. The present location is excellent. Any practical location of the MMD in the rear cockpit would be a poorer location for display of these warnings. The existing indicator contains both warnings and cautions, some of which are classified. However, all of the messages can be displayed on the MMD without difficulty. As mentioned in the situation regarding the front cockpit, our Human Factors Group takes a dim view of eliminating the existing dedicated warning indications with the installation of an MMD. However, it would appear that the "heads up" requirement for warning indication in the rear cockpit is not as critical as for the front cockpit, since the pilot is flying the aircraft and the NFO is not.

SUMMARY OF WEIGHT, VOLUME, AND POWER DELTAS

The CAI uses a maximum of 212 watts of power from the aircraft's 28 vdc supply. It is estimated the MMD will require approximately 300 watts. This represents an increase of about 88 watts. The front cockpit CAI weighs 5.5 lb and has a volume of 191 cu in. The MMD as proposed consists of a display unit and an electronics package. The weight of the display unit is 12 lb with a volume of 394 cu in. The electronics package weighs 10 lb, and has a volume of 189 cu in. The totals for the two units are 22 lb and a volume of 583 cu in. The weight and volume increase because of the MMD will be 16.5 lb and 392 cu in.

The MMD as proposed, provides for only the CAI to be eliminated and replaced by the MMD, and in the front (pilot) cockpit only. Elimination of the discrete warning indicators (Wheels, Threat, and Fire) would reduce the weight differential by approximately one pound. However, this is not recommended.

MMD DESIGN

A functional block diagram of the MMD is shown in Figure 28. A description of the functions of each block shown in the diagram follows:

Interface

The interface block contains circuits to perform the following functions:

1. Sampling of inputs
2. Signal conditioning
3. Disabling of normal input information and application of test inputs during test conditions.

Input sampling is accomplished by use of a Data Selectors/Multiplexer such as shown in Figure 29. The microprocessor programs the sequence of input signal addresses to be decoded by the Data Selector, thereby enabling each input in sequence. If the one of eight type of Data Selector is used, ten units will be required to accommodate all input

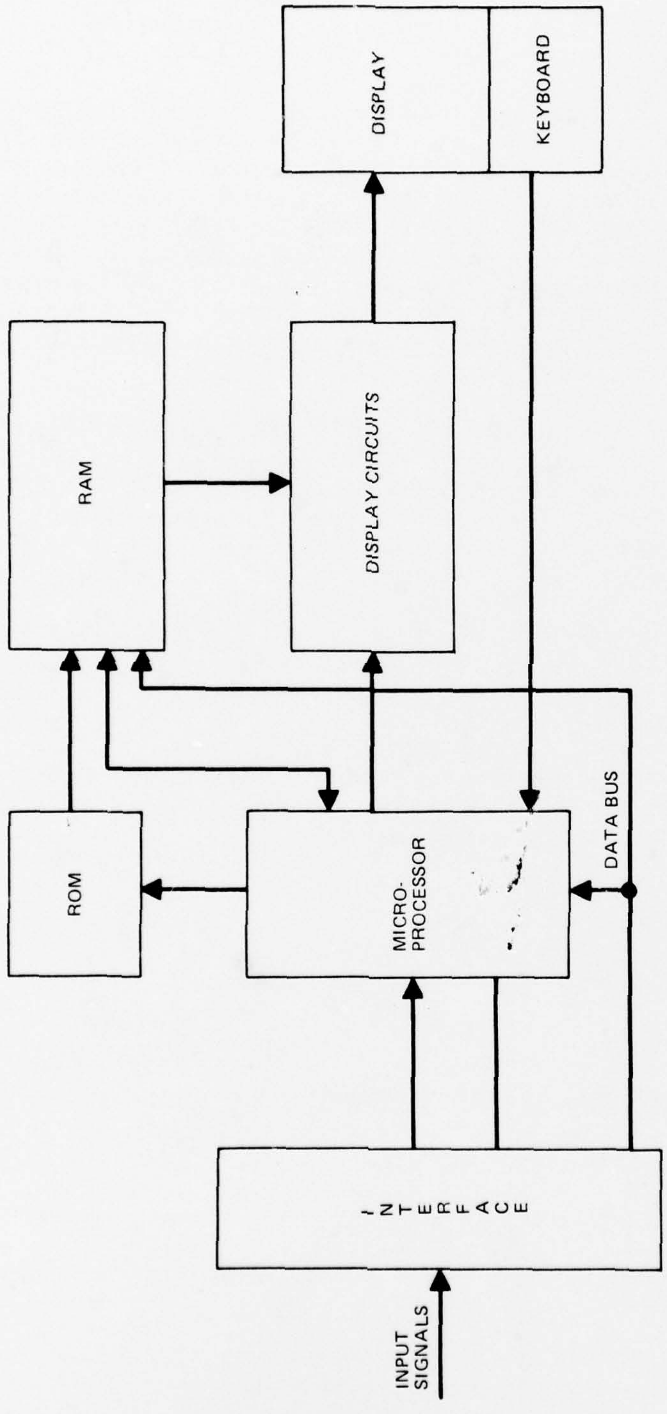


Figure 28. Functional Block Diagram of MMD

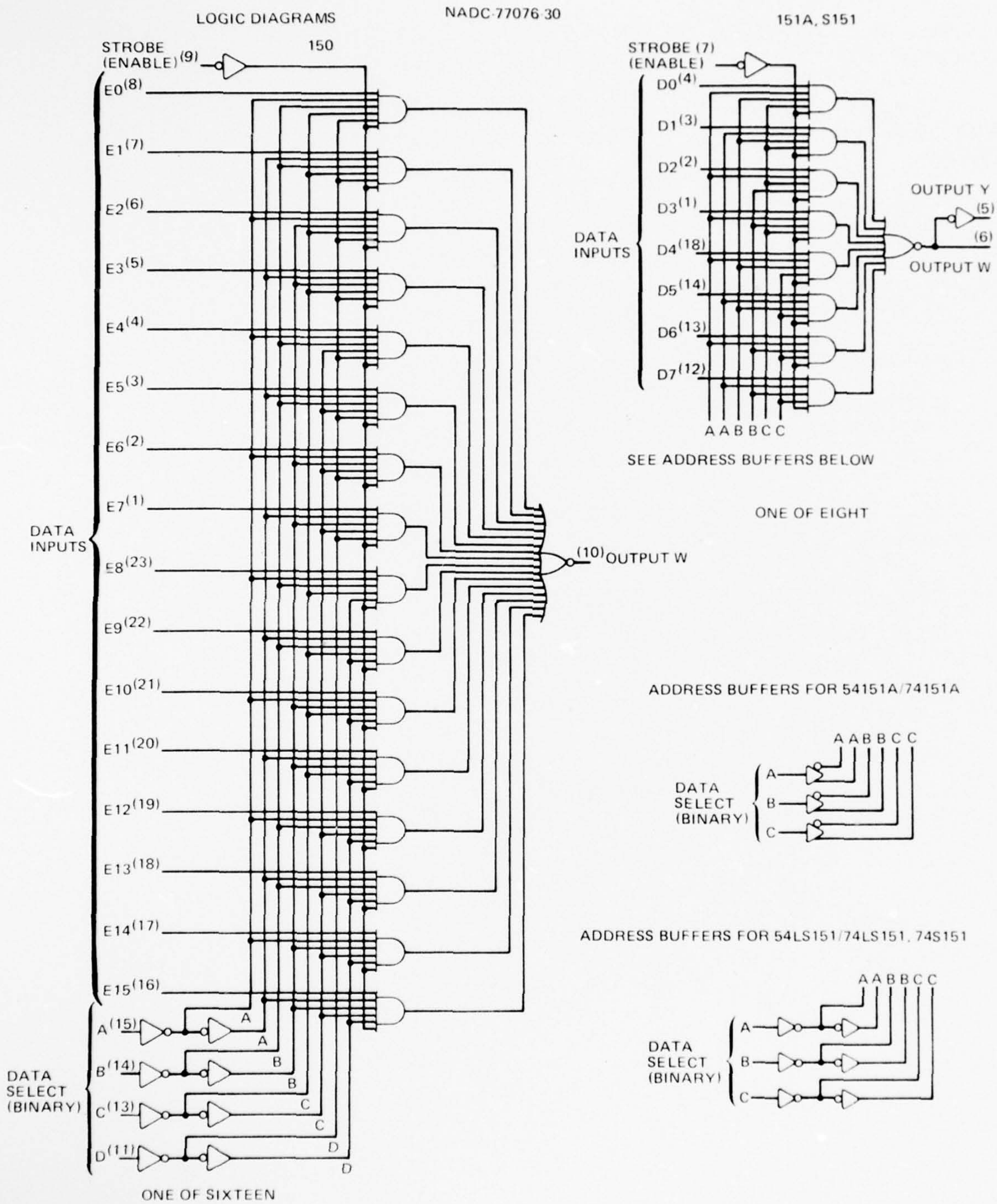


Figure 29. Data Selectors/Multiplexers

signals. Since each of the ten, one of eight Data Selectors must also be selected in sequence, additional bits will be included in the address word for this purpose.

To achieve uniform go/no go criteria for all of the input signals, signal conditioning is required. The input signals contain the following types of go/no go criteria:

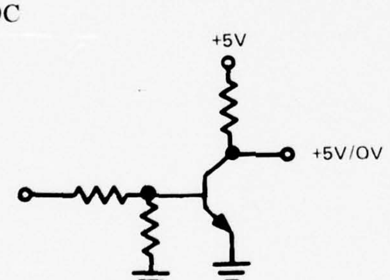
Go (inactive)/No Go (active)

- Open Circuit/+28v
- +4.5V/OV
- Ground/Open Circuit
- Open Circuit/Ground
- Sat. Transistor/Cutoff Transistor.

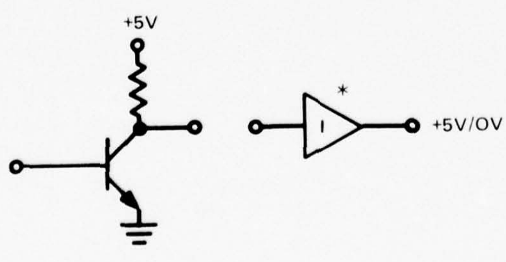
The following types of input conditioning circuits can be used to achieve the desired uniform go/no go criteria:

Input types

Open Circuit/+28VDC

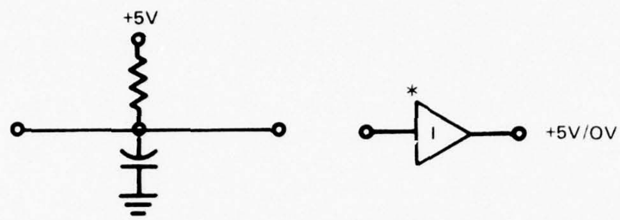


+4.5V/OV, Sat. Trans/CO Trans

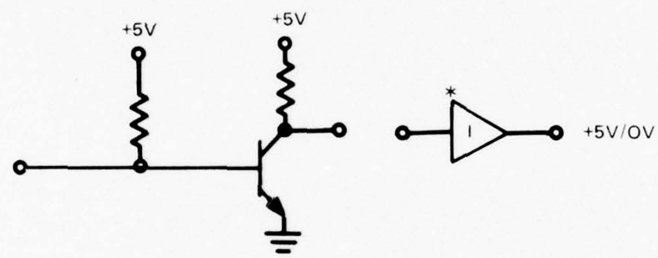


*Inversion Required

Ground/Open Circuit



Open Circuit/Ground



*Inversion Required

Display Circuits

The display circuits convert the contents of the RAM for display of alphanumeric information, position this information on the CRT, and generate the display refresh at a rate of 60 times per second.

Microprocessor

The microprocessor is the heart of the system. It programs the sampling of inputs both during normal and during test conditions, detects and stores faults, and identifies the block of data in ROM that should be displayed. When a fault is detected, the microprocessor, depending upon the input being sampled, locates the position in the ROM where the appropriate fault and course of action information is stored. The microprocessor then causes that block of information to be transferred into the RAM for display. The microprocessor also performs the necessary logic to establish display priority, and generates all necessary timing signals.

Display

The display is the actual readout for all messages to be furnished to the pilot. A CRT type display seems to be the most practical approach at this time because it represents a tried and proven approach to the man-machine interface for data presentation. A keyboard with both function and numeric keys is provided to allow various display selection and cancellation.

The block diagram (Figure 28) shows a data bus that is not required for the F-14 application. It is included for flexibility and compatibility with the other AIDS displays.

ROM

The ROM is the data bank for all fault and course of action information. In addition, any other read only type of information such as pre-takeoff and landing checklist information would be stored here, should it be desired that this feature be included in the MMD. As proposed, no such checklist information is included in the MMD. As indicated elsewhere in this report, the ROM will require 120K bits of storage for the fault course of action information.

RAM

The RAM contains the refresh memory for the block of data being displayed on the CRT at any given time. The RAM also contains the status information for each input. In addition, fault history information is contained in a non volatile portion of the RAM. Finally, the RAM contains provisions for any required temporary storage of information for such purposes as are required for the operation of the MMD as proposed. The RAM capacity has been tentatively estimated at 10K bits.

Display Design

The proposed MMD design makes use of a standard CRT. The tentative decision to use a CRT was made for the following reasons:

- Considering the flat panel readouts such as liquid crystal, LED, Plasma, etc., it appears that the liquid crystal is the only one considered to have sufficient contrast ratio under high ambient lighting conditions to allow usage in the F-14 cockpit.

- The liquid crystal display shows promise for overcoming the "washout" problem inherent in all CRT displays. However, the present "state-of-the-art" is such that the liquid crystal would represent a high risk approach. In addition, character size and display capability may be a problem. It is our understanding that the liquid crystal display being developed by Hughes measures 5 in. x 8 in. and provides 10 lines of 16 characters each for a total of 160 characters. In view of the vast amount of data required for the F-14 MMD (e.g. $\approx$ 1,000 characters contained in the hydraulic system checklist) and with a desire to hold multiple pages of information to a minimum, it is believed that the CRT has a decided advantage because, as shown below, more than 800 characters can be displayed on the proposed F-14 MMD. In the future, should the advantages of the liquid crystal display outweigh those of the CRT, our approach has the flexibility to take advantage of the improved liquid crystal technology.

The proposed MMD design uses a CRT type KC 2739P that is $4\frac{1}{2}$ in. x $5\frac{1}{2}$ in., and has an overall length of $7\frac{1}{2}$ in. A $\frac{1}{4}$ in. area around the CRT is allowed for packaging. This CRT provides a usable display area of 4 x 5 in. A tradeoff of several acceptable character sizes and line spacing is shown:

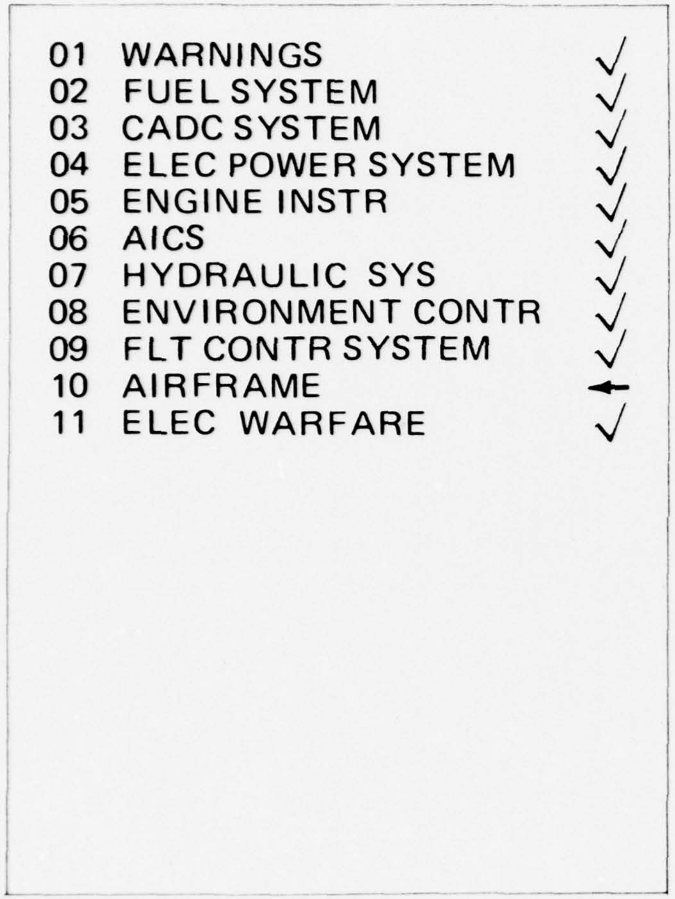
Character Height, in.	Line Space, in.	Lines Displayed	Char/ Line	Total Char
3/16	1/8	16	24	384
3/16	1/16	20	24	480
1/8	1/16	26	34	884

It is estimated that the distance from the pilot's eye to the MMD is about 36 in. with the proposed MMD mounting in the Pilot's Right Side Console. With this in mind, it appears that 1/8 in. high characters with 1/16 in. spacing are acceptable. In fact, the present CAI in the same location uses 1/8 in. high characters. However, a greater margin of readability is provided by the use of 3/16 in. characters with 1/8 in. line spacing. This is the recommended combination. This character size provides an advantage in message acquisition, particularly during time of Pilot high work loading. In either case, character width shall be 3/5 of character height, except for the "I" which shall be one stroke width, and the "M", and "W", which shall be 4/5 of the height. Stroke width shall be 1/6 the height of the characters. Character spacing shall be one stroke width minimum. Word spacing shall be one character width. Examples of displays using different character heights are shown in Figure 30.

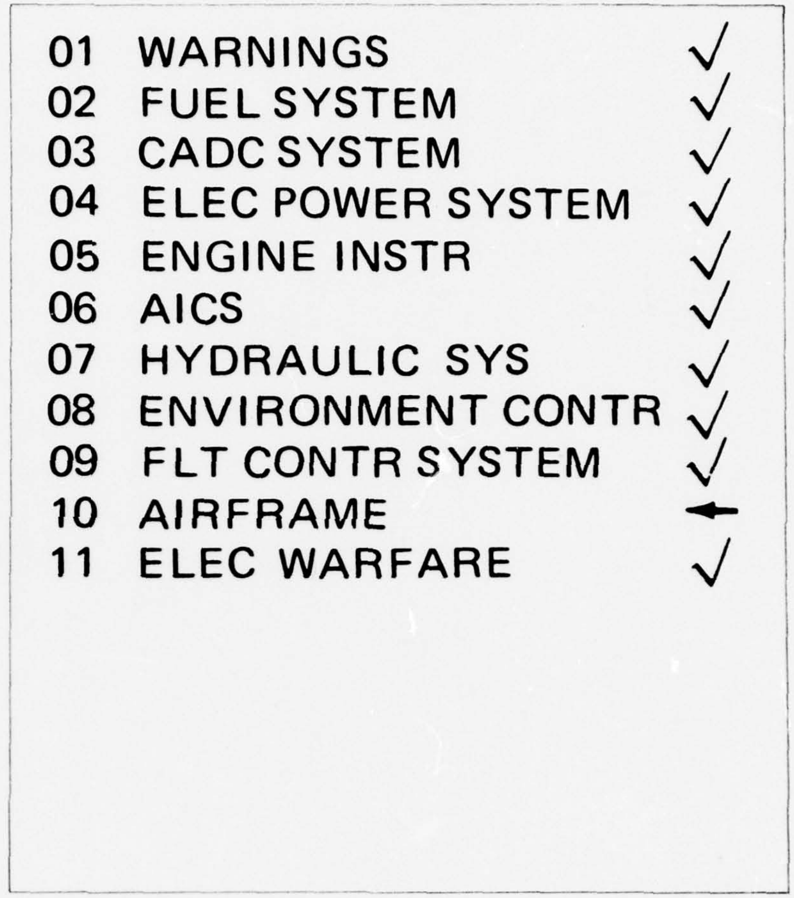
RECOMMENDED FORMAT FOR DISPLAY OF INFORMATION

The recommended approach for getting the required MMD messages to the pilot is the automatic display of fault and course of action, in page format for all detected faults. The fault will be listed at the top of the page. The required action to be taken will be listed beneath the fault. Examples of typical fault messages are shown in Figures 31 through 34. Of the approaches considered, such as recorded messages, and supplying course of action manually if needed, this approach gets the message to the pilot in the least amount of time and with good reliability. The recorded voice message approach is subject to background noise interference. The manually selected course of action, when needed, is slower than the automatic display. Also, there may be a tendency for the pilot to resort to memory instead of the checklist. Automatic display of this information will lessen this tendency, reducing the chance of error.

Actual photographs of simulated displays are shown in Figures 35 through 38. These displays were simulated using equipment that does not provide the checks (√) and arrows (←) to indicate status as outlined in this report. In these photographs, +, and <<< symbols are used to indicate go, and no go conditions, respectively. Fig. 25 shows an All Systems Summary indicating a faulty Flight Control System. Selecting the Flight Control System would result in the display shown in Fig. 36 indicating the faulty subsystem – in this case, Roll Stab. 1 and 2. Figs. 37 and 38 show the message that would result if the Fault pushbutton was depressed.



1/8 IN. CHARACTERS, 1/16 IN. LINE SPACING



3/16 IN. CHARACTERS, 1/8 IN. LINE SPACING

Figure 30. Examples of Display Character Size

REDUCE SPEED
1. DECEL TO < 280 KIAS
2. CHECK FLAP HANDLE 0°
3. MASTER RESET DEPRESS
   THEN REPEAT CMD

TYPICAL WARNING MESSAGE

ROLL STAB 1 OR 2 FAILURE
CYCLE AFFECTED STAB AUG
SW. NO CORR ACTION OR
LIMITATIONS

TYPICAL CAUTION MESSAGE

Figure 31. Typical Warning and Caution Messages

GLOVE VANE
L FUEL PRESS
L FUEL LOW
GLOVE VANE
1. CHECK HYD PRESS
2. MANEUVER DEVICES-RETRACT
3. MASTER RESET-DEPRESS
L FUEL PRESS
1. NO A/B 15K FT ON
AFFECTED ENGINE
2. FUEL DISTR-MONITOR/
BALANCE
3. LAND ASAP
CONT'D NEXT PAGE

L FUEL LOW
1. DUMP SW-OFF
2. FUEL DISTR-CHK-BAL
IF WG/EXT FUEL REMAINS:
3. WG/EXT TRANS SW-ORIDE

Figure 32 Typical Multiple Caution Fault Display (Two Pages)

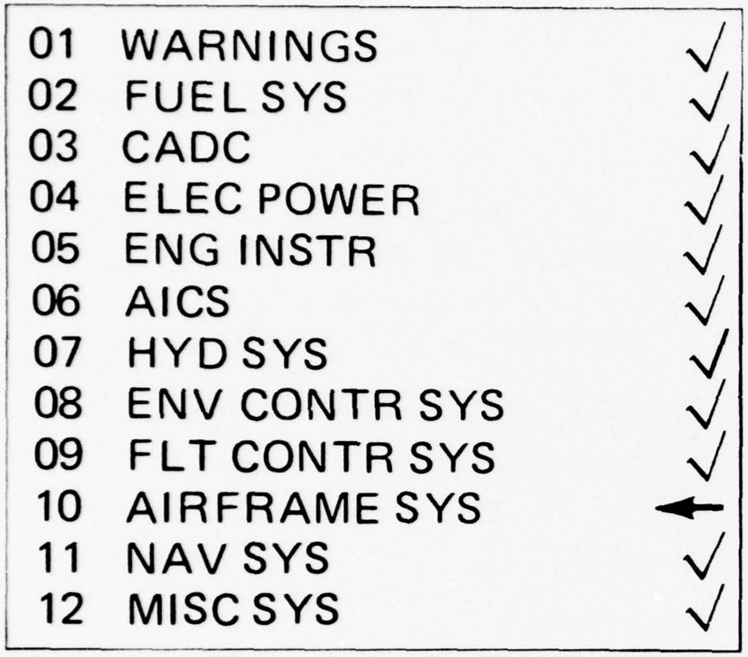
ROLL STAB 1 AND 2 FAILED
1 AIRSPEED-DECEL TO STAB
LIMITS
PITCH-0.93 IMN
ROLL-0.93 IMN
2 WAIT 10 SEC FOR SELF TEST
3 RECHECK FAULTS
IF ONE FAULT (1 OR 2) GOES
AWAY, RESET STAB AUG-NO
LIMITS
IF BOTH FAULTS REMAIN
1 LEAVE STAB AUG OFF
2 STAY BELOW STAB LIMITS
CON'T NEXT PAGE

FIRST PAGE

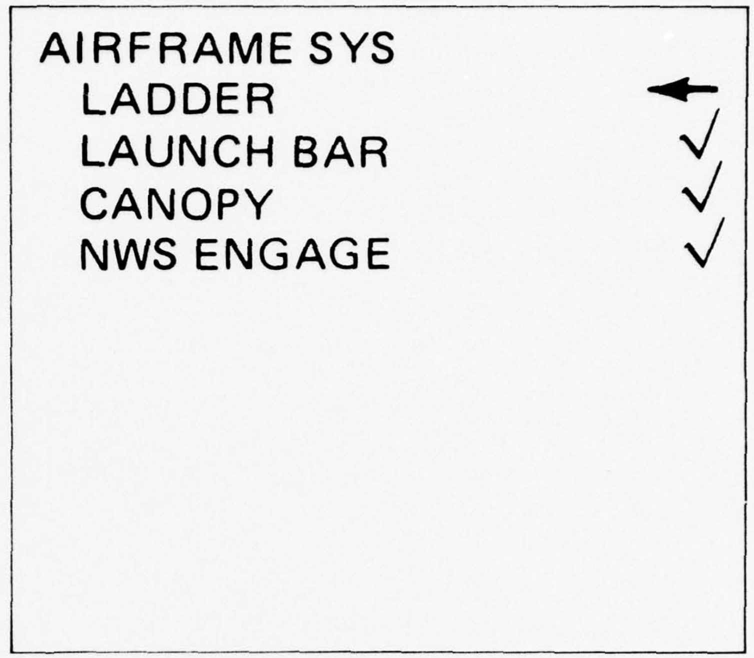
ROLL STAB 1 AND 2 FAILED
WARNING:
DO NOT ENGAGE ACLS OR DLC

SECOND PAGE

Figure 33 Typical Caution Message (Two Pages)



MANUALLY SELECTED ALL SYSTEM STATUS SUMMARY



SELECTING 10 AIRFRAME SYS GIVES THIS DISPLAY

Figure 34 Typical Manually Selected Displays

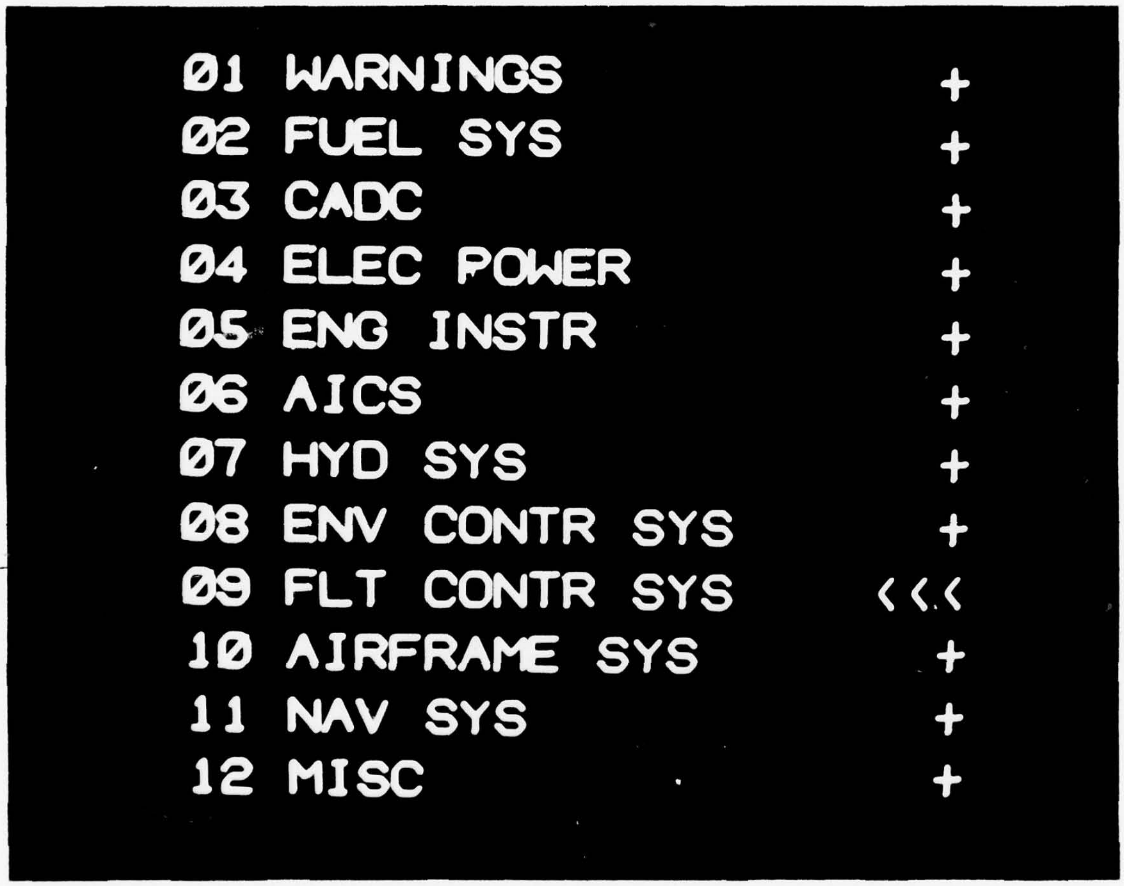


Figure 35. All Systems Summary

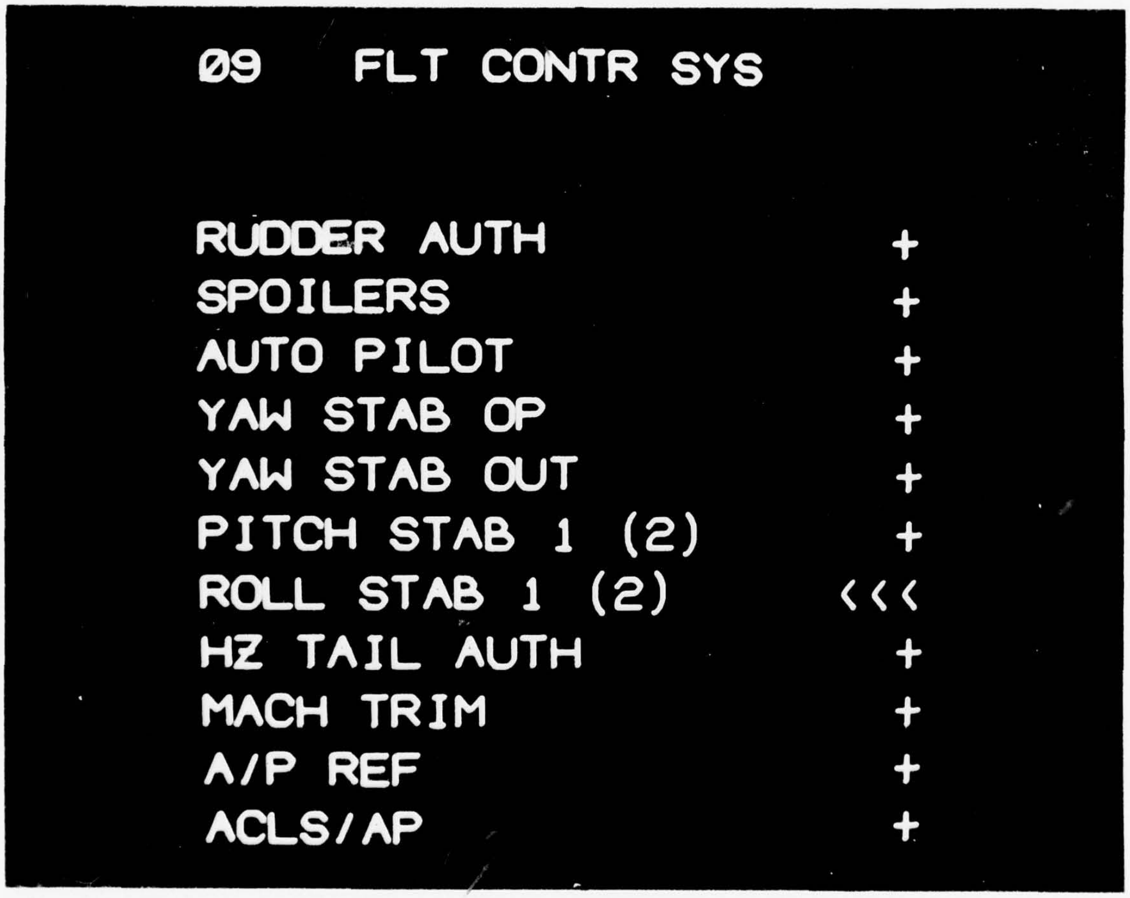


Figure 36. Faulty Sybsystem Indication

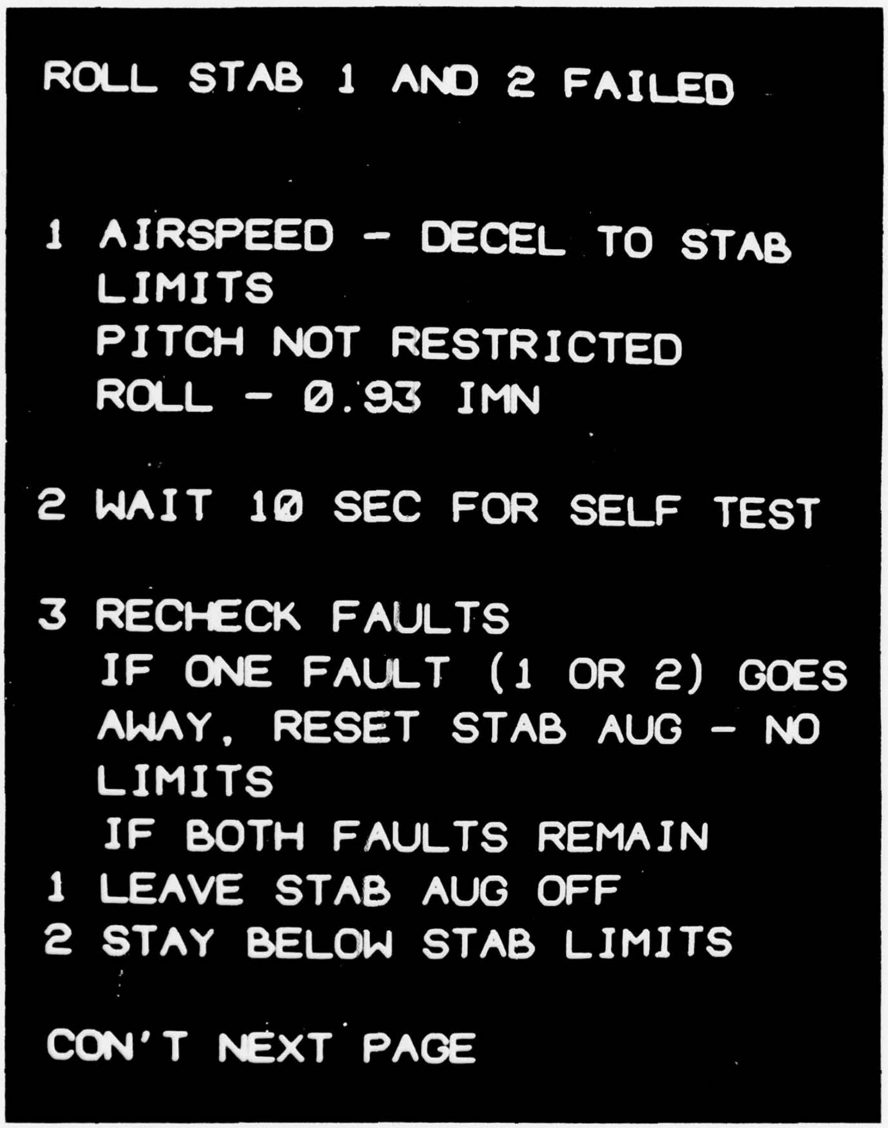


Figure 37. Fault Caution and Course of Action Display (Page 1)

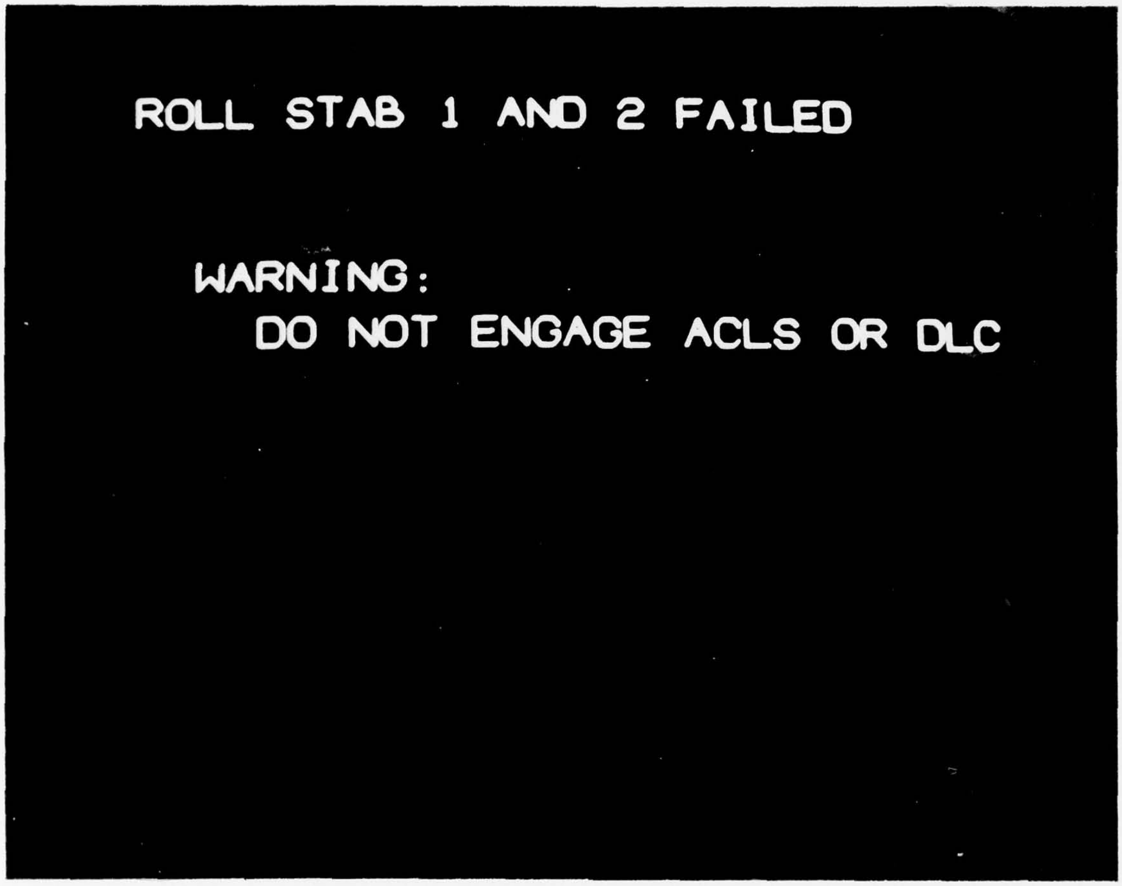


Figure 38. Fault Caution and Course of Action Display (Page 2)

SHOPPING LIST OF COMPLEXITY VS AMOUNT OF INFORMATION DISPLAYED

The following is a list of levels of complexity required for the MMD to achieve greater capability:

- Design an MMD using the CAI interface as it exists in F-14. This would provide the simplest and most economical MMD. Basically the difference between this MMD and the CAI would be the display of course-of-action information.
- Make minor modifications to the interface signals. Capability is increased resulting in some decision making, more specific fault indication, and, therefore, display of more effective course of action information. This is the proposed MMD.
- Add Hydraulic Checkout Feature (HYCOS). This is covered in this report, and is a recommended addition to the proposed MMD design.
- Add new sensors (Table 4) and multiplexing as outlined in Task 3.
  - This would provide quantitative information on these parameters.
  - Wiring would be reduced and MMD design simplified. This is discussed in this report and is a major modification.
- Add Audio Cues and/or Voice Messages
  - Potentially, tones can result in faster reaction times than visual cues. However, they can be troublesome because they can be interfered with or masked by other tones or sounds, resulting in missed cues.
  - Recorded voice messages alone result in slower reaction times when compared to indicator lights. However, combining the two (indicator lights with recorded messages) should result in improved reaction times when compared to indicator lights alone. Care must be exercised in the use of audio cues, particularly in the use of tones. The use of recorded messages in combination with visual cues has merit. However, Grumman is not proposing the use of these, or any additional audio cues beyond those already in use in the F-14.
- An MMD could be adapted to provide Onboard Checkout (OBC) types of information. The F-14 already has an OBC, but the capability is there.

TASK 3

Task 3 contains the following:

- Description of operation
- Summary of implementation problems
- Additional hardware requirements
- A profile showing the proposed location of the Electronics Unit of the MMD
- Recommendations.

The F-14 MMD Specification has been included in this report as Appendix A. This will allow this specification to be used apart from this report as a separate document. A summary of weight, volume, and power changes is included in Task 2. The Avionic Boilerplate Specification, F-14A-BP-68-1K, is included as Appendix B.

DESCRIPTION OF OPERATION

Operation and design of the MMD has been largely influenced by the AIDS philosophy of management by exception, and by the requirements of Mil-STD-411. In keeping with the AIDS philosophy for a no-fault condition, the suggested approach is to display nothing on the MMD. This approach, however, does allow for complete manual systems status monitoring at any time by depressing the All Systems select pushbutton. It might be pointed out that the present CAI system, and all existing warning indicators on the F-14 use this same philosophy, nothing displayed for a no-fault condition. This approach, along with the Built-In-Test (BIT) provisions, will provide the necessary high degree of confidence on the part of the crew for such a "management-by-exception" display. Regarding Mil-STD-411, it was questionable whether this document should apply to an MMD since, in a strict sense, it was written to cover lights and lighted legends, and not CRT displays. However, it does outline the requirements for aircrew station signals of the type displayed on an MMD. In addition, it applied to the CAI, which the MMD will replace. In this respect, it is believed that with the exception of a few minor considerations such as color requirements, the intent of this document could be met with a CRT display.

The categorizing of faults has been guided by MIL-STD-411, which defines three fault categories based upon severity and required action by the crew. These categories are warning, caution, and advisory in decreasing order of importance. Briefly, warnings indicate the existence of hazardous conditions requiring immediate action. Cautions indicate impending dangerous conditions requiring action, but not necessarily immediate action. Advisories indicate safe or normal conditions noteworthy of attention. With these factors in mind, an analysis of those advisory indication, which should be displayed for the pilot, indicates that they should be classified as cautions. If this is done, the category of advisory would be eliminated leaving only warnings and cautions to be displayed on the pilot's MMD.

All detected faults of the warning or caution categories cause automatic display of the fault and the prescribed course-of-action contained in the Pilot's Pocket Checklist. In the case of cautions (majority), the Master Caution (MC) indication is also triggered to alert the pilot to the caution message displayed on the MMD. Since the recommended approach retains all of the existing warning indications in the pilots cockpit (these are all located within the 30^{o} cone of vision), a Master Warning (MW) indicator is not necessary. The MC indication is required because of the location of the MMD.

Manual displays are selected as follows: Depressing the All SYS pushbutton causes the All Systems Status Summary to be displayed. This display is shown in Figure 33. Each of the systems listed has its unique number and its total status indicated by a check (✓) for no fault, or an arrow (←) for a fault situation. System selection is accomplished by depressing the appropriate keyboard digits that match the number of the system desired for display. This results in a display listing the selected system and its subsystems, along with the status of each subsystem. If the FAULT pushbutton is now depressed, all faults of the selected system are displayed along with the appropriate course of action information, in page format. If several pages are required, this is indicated by the caption CONT'D NEXT PAGE at the bottom of the display. The next page is displayed when the NEXT PAGE pushbutton is depressed. Finally, when the displayed information is no longer needed, it is cancelled by depressing the CANCEL pushbutton. In the case of warning messages, only the course of action portion of the display can be cancelled as long as the fault is present. The fault portion will remain on display as long as the fault exists. The first line of the display will be reserved to indicate any unremovable warning fault, or to indicate a caution fault that occurs while another caution fault and course of action is being displayed.

The purpose of the MEMORY pushbutton is to provide display of fault history information in chronological order of occurrence. This particular (Memory) storage unit will be nonvolatile for power interruption or shutoff. This is achieved by use of a small rechargeable battery. Under powered conditions, a trickle charge circuit keeps the battery charged up. If power is interrupted or shut off, the battery will hold the state of the memory storage. At the beginning of a mission, the memory would be reset by simultaneously depressing both the CANCEL and MEMORY pushbuttons. This would clear the nonvolatile memory of any old information. It is believed that this feature will be very helpful for debriefing and possibly crash investigation purposes because it provides a record of fault information. The layout of the MMD front face is shown in Figure A-1 of the MMD Specification, Appendix A.

The fault category priority system dictates that warnings have priority over all other categories, while cautions have priority over advisories. The MMD as proposed does not contain any advisory faults. A warning and a caution occurring simultaneously results in the automatic display of the warning fault and course of action. The caution fault would be stored. Its existence is indicated by the MC. It will be displayed automatically when the warning message is cancelled. A higher priority fault occurring while a fault message is being displayed results in the automatic cancellation of the existing display, and the display of the higher priority message. The lower priority message will be redisplayed upon cancellation of the higher priority message. A fault of the same priority occurring while a fault message is being displayed results in the new fault being added to the existing display (in the reserved top line of the display) without course of action information, a MC indication, if the fault is a caution, and automatic display of the new fault and course of action when the existing display is cancelled. A lower priority fault occurring while a fault message is being displayed results in a MC indication if the new fault is a caution, and automatic display of the new fault and course of action when the existing display is cancelled. When two or more warning or cautionary faults in the same fault category occur simultaneously a preview listing of the faults is displayed automatically without course of action information. Beneath this preview listing, the faults with course of action information are displayed in page format. Several pages are used if necessary. Each page is available on a rotating basis by use of the NEXT PAGE pushbutton, until the message is cancelled by use of the CANCEL pushbutton. Typical examples of the various displays are shown in Figures 21 through 24.

SUMMARY OF IMPLEMENTATION PROBLEMS

Installation

A major problem of implementing an MMD in the F-14 is finding a location that would have minimum impact on the F-14 cockpit. In Figure 27 the AIDS cockput layout is shown with the MMD located to the right of the Vertical Situation Display (VSD). This layout is applicable to a complete AIDS configured aircraft. This location is possible because the space occupied by the various AIDS display results from the deletion of most of the presently existing cockpit instruments. The five AIDS displays incorporate all of the information displayed on the deleted instruments. This study, however, deals with replacing the CAI with an MMD. After much consideration, it appears that the installation having least impact on the cockpit, and appears to be the only practical location in the front cockpit, is the area presently occupied by the CAI. The MMD width would be fixed by the mounting rails in the cockpit. Depth is also restricted to about 7 inches. Considering these constraints, an MMD design is proposed that requires the movement of only three panels, adjacent to the CAI, approximately 4 inches toward the rear, to provide mounting space for the MMD unit. Figure 39 shows the required modification, and Figure 40 shows the Display Unit installed. Figure 41 shows the tentative location of the Electronic Unit of the MMD in the circled area, above the box numbered 9.22. The estimated size of the Electronics Unit is 4 x 7 x 9 inches, while the weight, exclusive of cables is estimated to be 10 pounds.

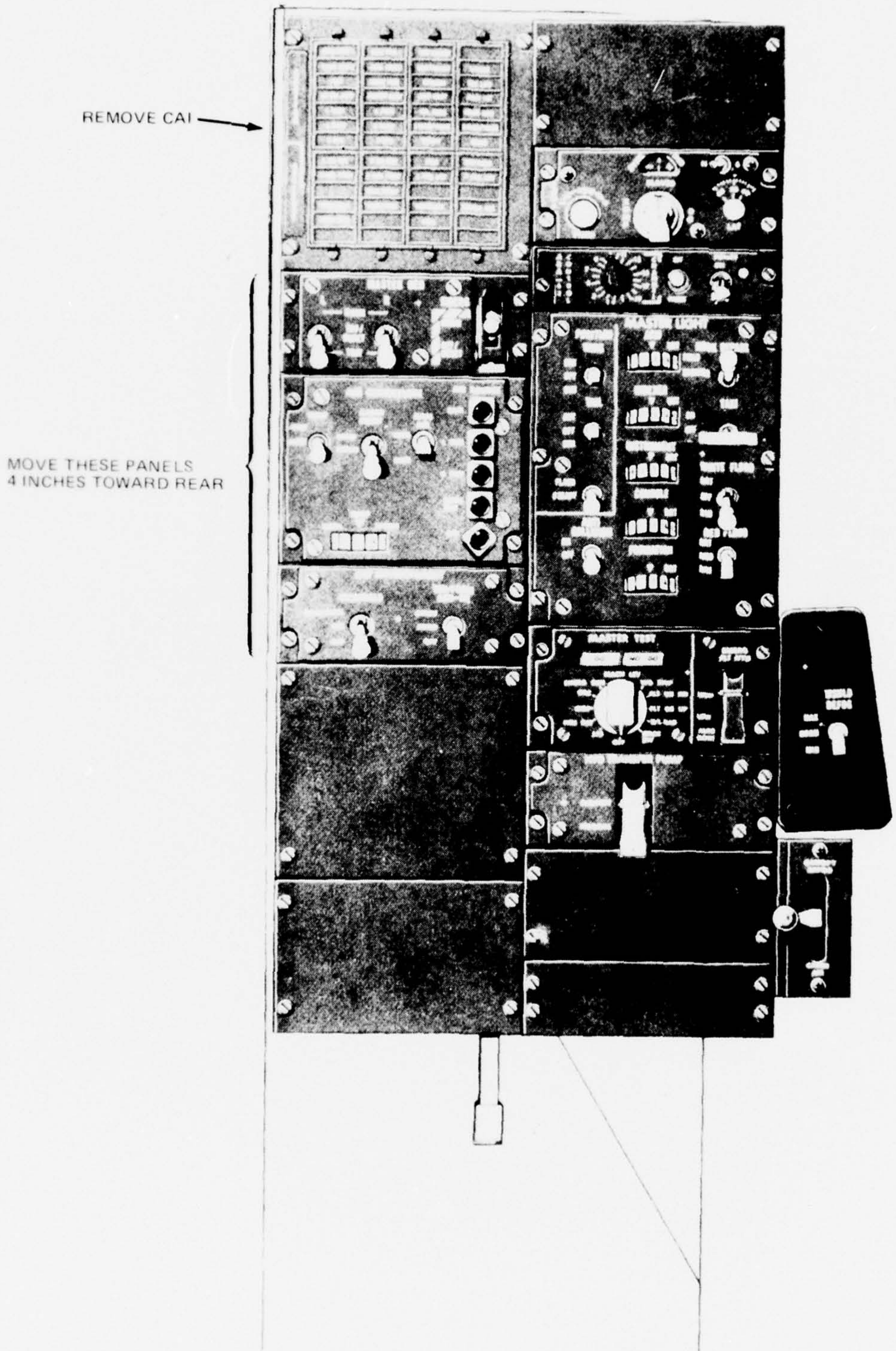


Figure 39. Pilot's Right Side Console

MMD

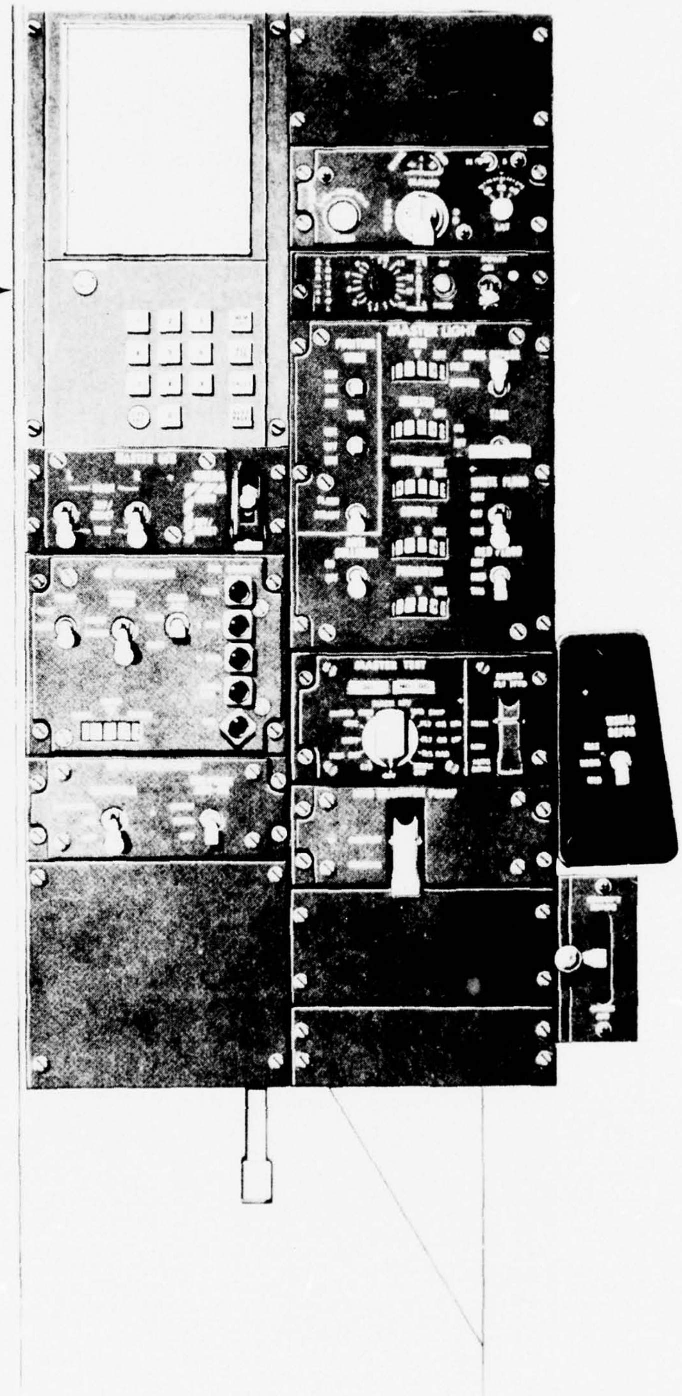
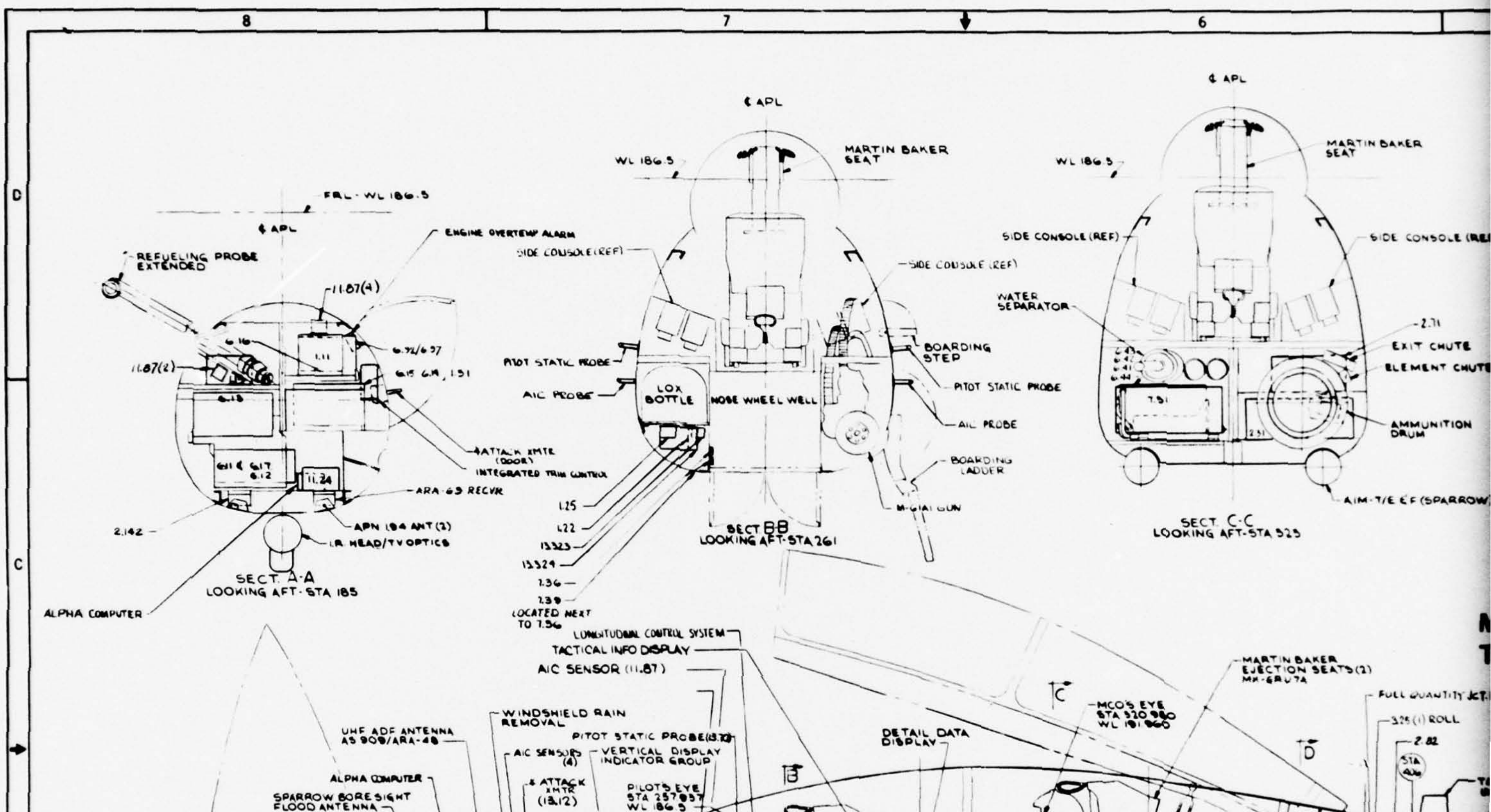


Figure 40. Pilot's Right Side Console With MMD



8
7
6
D
C
B
A
¢ APL
FRL - WL 186.5
REFUELING PROBE EXTENDED
ENGINE OVERTEMP ALARM
11.87(4)
11.87(2)
6.16
1.11
6.92/6.97
6.15 6.14 1.51
6.13
6.11 & 6.17 6.12
11.24
ATTACK XMTR (DOOR)
INTEGRATED TRIM CONTROL
ARA-63 RECVR
APN 194 ANT (2)
I.R. HEAD/TV OPTICS
2.142
SECT. A-A
LOOKING AFT-STA 185
ALPHA COMPUTER
WL 186.5
MARTIN BAKER SEAT
SIDE CONSOLE (REF)
SIDE CONSOLE (REF)
PITOT STATIC PROBE
AIC PROBE
LOX BOTTLE
NOSE WHEEL WELL
BOARDING STEP
PITOT STATIC PROBE
AIC PROBE
BOARDING LADDER
M-61A1 GUN
1.25
1.22
13.323
13.324
1.36
2.39
LOCATED NEXT TO 7.56
SECT B-B
LOOKING AFT-STA 261
WL 186.5
MARTIN BAKER SEAT
SIDE CONSOLE (REF)
SIDE CONSOLE (REF)
WATER SEPARATOR
2.71
EXIT CHUTE
ELEMENT CHUTE
7.51
2.31
AMMUNITION DRUM
AIM-7/E CF (SPARROW)
SECT. C-C
LOOKING AFT-STA 325
LONGITUDINAL CONTROL SYSTEM
TACTICAL INFO DISPLAY
AIC SENSOR (11.87)
WINDSHIELD RAIN REMOVAL
UHF ADF ANTENNA AS 909/ARA-48
PITOT STATIC PROBE (13.12)
AIC SENSORS (4)
VERTICAL DISPLAY INDICATOR GROUP
ALPHA COMPUTER
ATTACK XMTR (13.12)
PILOTS EYE STA 257.937 WL 186.5
SPARROW BORE SIGHT FLOOD ANTENNA
AOA FILTER CONTROL
REG VALVE
ARA-63 RECVR
AWG-9/VFX RADAR ANTENNA 6.19 REF
ALPHA PROBE
DETAIL DATA DISPLAY
MCO'S EYE STA 320.980 WL 191.960
MARTIN BAKER EJECTION SEATS (2) MK-GRU7A
FULL QUANTITY
3.25 (1) ROLL
2.82
BOARDING STEP (2)
1.75
6.20
6.22
6.23
9.22
1.11
6.15
6.14
11.24
3.31
9.12
2.71
2.31
1.41
FUEL
AWG-9 HORN WAVEGUIDE (6.18)
STA 83.44
IFF INTER ANTENNA APX-76
INFRARED SEEKER/TV OPTICAL UNIT 6.91/6.96
STA 176
A
2153
M-61A1 GUN
2.156
STA 215
FLASHER 11.21
B
C
AMMUNITION DRUM
EXTERNAL POWER RECEPTACLE
STA 345
ALR 50 ANTENNA
AIC PROBE (11.86)
2.15
2.60
ARA-63 DECODER
D
COUPLER SPLITTER
STA 395
AIM-7/E CF (SPARROW) AT BL 21
DIPLEXER
RAIN REPELLANT CONTAINER
CANOPY JETTISON HANDLE
SYS PWR/GND TEST PANEL
VIEW
ALQ 100 ANTENNA (FWD LOOKING)
ALQ 100 ANTENNA (AFT LOOKING)
LAUNCH BAR
FUEL LEAK DETECTOR CONTROLLER
ENGINE OVERTEMP ALARM
GUN GAS PURGE UNIT
BOARDING LADDER (OPEN POS)
M-61A1 GUN CONTROL FILTER
FWD BOBWEIGHT LONGITUDINAL
ARA-63 ANTENNA
APN-194 ANTENNA
HYBRID COUPLER ALQ-100
ANTI SKID BOX (NWW) 11.80
FLAG INDICATOR (N.W.W.) 6.21
INTEGRATED TRIM CONTROL

2

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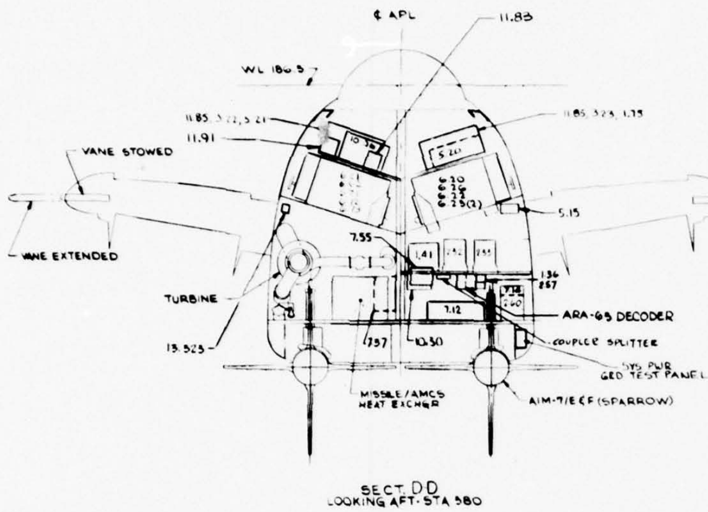


EQUIP LIST

ELECTRONIC EQUIPMENT LIST

1.00 NAVIGATION

- 1.11 INERTIAL MEASUREMENT UNIT AN/ASN-92
- 1.13 POWER SUPPLY (I.N.U.)
- 1.21 DISPLACEMENT GYRO SBK-11/A24G-26
- 1.22A ELEC CONT AMPL ASK-26/A24G-27
- 1.25 COMPENSATOR MXU-394/A
- 1.31 RCVR-XMTR RT/ARN-84
- 1.36 SWITCH RADIO FREQUENCY SA-521/A
- 1.38 DIPLEXER CU-1978/A
- 1.41 AMPL-RELAY ASSY AM-3624/ARA-50
- 1.50 COMPUTER AIR DATA CP-1055/A
- 1.75 COMPUTER SIG DATA CONV
- 1.91 RCVR/XMTR RADAR ALT APN 194(V)

2.00 COMMUNICATIONS

- 2.21 RCVR/XMTR RT-859/APX 72
- 2.23 COMPUTER KIT-1A/T SEC
- 2.25 LOBING SW 1474/A
- 2.26 TEST SET, AIRBORNE TS-1843/APX
- 2.29 DIPLEXER CU-1978/A
- 2.31 RCVR/XMTR RADAR RT-868A/APX-76
- 2.32 SYNCHRONIZER SN416A/APX-76
- 2.33 SWITCH AMPL SA-1568A/APX-76
- 2.36 COMPUTER KIR-1A/T SEC
- 2.41 T SEC JULIET 28 (CRYPTOGRAPHIC)
- 2.51 RCVR/XMTR RT 1194/ARC 159A(V)5
- 2.57 SWITCH, RADIO FREQUENCY GS839GR1
- 2.59.1 DIPLEXER CU-1978/A
- 2.60 INTERFERENCE BLANKER MX-6770/U
- 2.71 CONVERTER DDA CV-2441/ASW-27
- 2.82 SWITCH, RADIO FREQUENCY SA-521/A
- 2.87 DIPLEXER CU-1978/A
- 2.112 DIPLEXER CU-1978/A
- 2.142 MOD X-BAND BEACON MD-817/APN(S.W.P.)
- 2.151 RCVR/XMTR RT-7630/APN-154
- 2.153 DUPLEXER CU-1104/APN-154
- 2.154 MODULATOR X BAN BEACON

3.00 FLIGHT CONTROLS

- 3.21 COMPUTER-YAW FLT. CONTROL
- 3.22 COMPUTER-PITCH FLT. CONTROL
- 3.23 COMPUTER-ROLL FLT. CONTROL
- 3.25 RATE SENSOR ASSY, PITCH, ROLL & YAW
- 3.26 ACCELEROMETER ELEC LINEAR
- 3.31 COMPUTER THROTTLE CONTROL
- 3.34 ACCELEROMETER ELEC LINEAR

5.00 ALTERNATE WEAPONS CONTROL

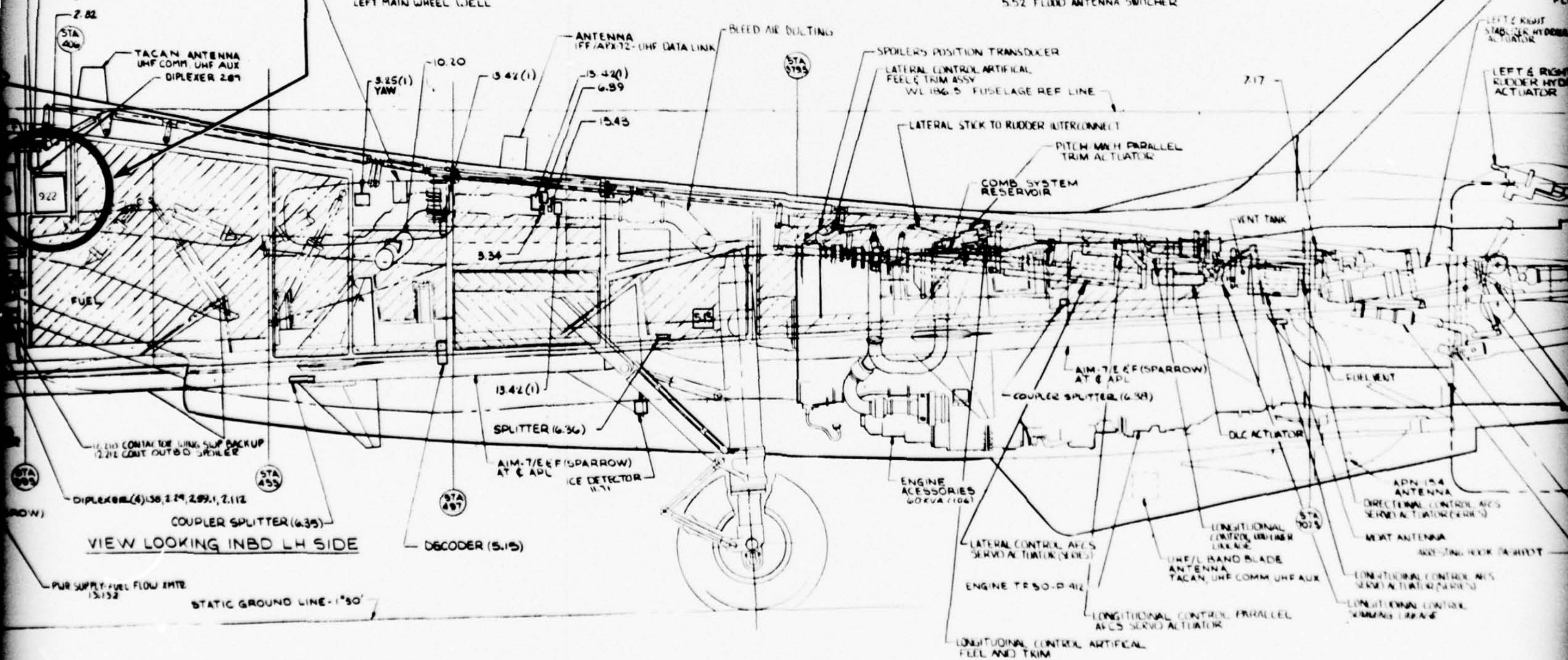
- 5.11 SWITCHING UNIT PWR SA-1749/AWG-15
- 5.14 DECODER COMMAND SIG KY-695/AWG-15(2)
- 5.15 DECODER COMMAND SIG KY-694/AWG-15 (4)
- 5.20 PWR SUPPLY (FUZE FUNCTION PP-6419/AWW-4(V).
- 5.40 CONTROL UNIT GUN C-8571/A
- 5.52 FLOOD ANTENNA SWITCHER

6.00 WEAPONS CONTROL AWG-9/VFX

- 6.11 OSCILLATOR RADIO FREQ MASTER
- 6.12 TRANSMITTER CONTROL SYNC
- 6.13 TRANSMITTER RADAR
- 6.14 POWER SUPPLY PP-6770/AWG-9
- 6.15 POWER SUPPLY PP-6771/AWG-9
- 6.16 POWER SUPPLY SOLENOID CURRENT
- 6.17 RECEIVER RADAR
- 6.18 HORN WAVEGUIDE
- 6.19 ANTENNA RADAR
- 6.20 CONTROLLER ANT & TEST
- 6.22 CONV SIGNAL DATA DOPPLER PROC
- 6.25 FILTER MULTIPLEXER
- 6.26 CONV SIGNAL DATA LOW PRF
- 6.35 CPLR DIR-PWR SPLTR
- 6.36 CPLR DIR-RF
- 6.38 CPLR PWR SPLTR RF
- 6.39 CPLR DIR PWR SPLTR
- 6.41 COMPUTER DIG, DRO A&C
- 6.42 PROCESSOR COMPUTER I/O
- 6.43 PWR SUPPLY-STORES, COMPUTER
- 6.44 STORER, COMPUTER NDRO
- 6.57 MISSION RECORDER
- 6.61 POWER SUPPLY PP-6773/AWG-9
- 6.62 POWER SUPPLY PP-6774/AWG-9
- 6.71 CONTROLLER LOGIC & TIMING
- 6.72 POWER SUPPLIES AIM-54A MISSLE
- 6.73 CON, SIGNAL-DATA MISSLE DATA
- 6.91 RCVR/REFRIG CRYOGENIC INFRARED
- 6.92 PROCESSOR DATA
- 6.96 TV OPTICAL UNIT
- 6.97 AMPLIFIER & PWR SUPPLY TV

7.00 ELECTRONIC COUNTERMEASURES

- 7.12 RADAR RCVR ALR 50
- 7.14 ANALYZER ELEC PULSE
- 7.17 PREAMPLIFIER (4)
- 7.31 RCVR/XMTR RT 848/ALQ 100
- 7.36 FLTR LO PASS HI PWR
- 7.36.1 SW ASSY RF
- 7.37 INITIATOR, DESTRUCT-IGNITOR MK
- 7.43 PROCESSOR VIDEO SIG CM-319(XA-1)AL
- 7.52 SWITCH SEQUENCER SA-1557/ALE-29A
- 7.52 SWITCH SEQUENCER SA-1874/ALE 39A (APL
- 7.53 CHAFF & FLARE DISPENSER AN/ALE 29A
- 7.39 HYBRID COAN
- 7.54 CHAFF & FLARE DISPENSER CUT OFF SWITCH
- 7.55 ECM SYS INTERFACE ADAPTER



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3

EQUIP LIST

ELECTRONIC EQUIPMENT LIST

1.00 NAVIGATION

- 1.11 INERTIAL MEASUREMENT UNIT AN/ASN-92
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- 2.31 RCVR/XMTR RADAR RT-868A/APX-76
- 2.32 SYNCHRONIZER SN416A/APX-76
- 2.33 SWITCH AMPL SA-1568A/APX-76
- 2.36 COMPUTER KIR-1A/TSEC
- 2.41 TSEC JULIET 28 (CRYPTOGRAPHIC)
- 2.51 RCVR/XMTR RT 1194/ARC 159A(V)5
- 2.57 SWITCH, RADIO FREQUENCY GS839GR1
- 2.59.1 DIPLEXER CU-1978/A
- 2.60 INTERFERENCE BLANKER MX-6770/U
- 2.71 CONVERTER DDA CV-2441/ASW-27
- 2.82 SWITCH, RADIO FREQUENCY SA-521/A
- 2.87 DIPLEXER CU-1978/A
- 2.112 DIPLEXER CU-1978/A
- 2.142 MOD X-BAND BEACON MD-817/APN(S.W.P.)
- 2.151 RCVR/XMTR RT-763D/APN-154
- 2.153 DUPLEXER CU-1104/APN-154
- 2.154 MODULATOR X BAN BEACON

3.00 FLIGHT CONTROLS

- 3.21 COMPUTER-YAW FLT. CONTROL
- 3.22 COMPUTER-PITCH FLT. CONTROL
- 3.23 COMPUTER-ROLL FLT. CONTROL
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- 5.15 DECODER COMMAND SIG KY-694/AWG-15 (4)
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- 5.40 CONTROL UNIT GUN C-8571/A
- 5.52 FLOOD ANTENNA SWITCHER

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- 6.12 TRANSMITTER CONTROL SYNC
- 6.13 TRANSMITTER RADAR
- 6.14 POWER SUPPLY PP6770/AWG-9
- 6.15 POWER SUPPLY PP6771/AWG-9
- 6.16 POWER SUPPLY SOLENOID CURRENT
- 6.17 RECEIVER RADAR
- 6.18 HORN WAVEGUIDE
- 6.19 ANTENNA RADAR
- 6.20 CONTROLLER ANT & TEST
- 6.22 CONV SIGNAL DATA DOPPLER PROC
- 6.23 FILTER MULTIPLEXER
- 6.26 CONV SIGNAL DATA LOW PRF
- 6.35 CPLR DIR-PWR SPLTR
- 6.36 CPLR DIR-RF
- 6.38 CPLR PWR SPLTR RF
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- 6.43 PWR SUPPLY-STORES, COMPUTER
- 6.44 STORER, COMPUTER NDRO
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- 6.73 CON, SIGNAL-DATA MISSLE DATA
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- 7.17 PREAMPLIFIER (4)
- 7.31 RCVR/XMTR RT 848/ALQ 100
- 7.36 FLTR LO PASS HI PWR
- 7.36.1 SW ASSY RF
- 7.37 INITIATOR, DESTRUCT-IGNITOR MX7832/ASQ
- 7.43 PROCESSOR VIDEO SIG CM-319(XA-1)ALR-23(SWP)
- 7.52 SWITCH SEQUENCER SA-1557/ALE-29A (APL 1 THRU 38)
- 7.52 SWITCH SEQUENCER SA1874/ALE 39A (APL 39 & ON)
- 7.53 CHAFF & FLARE DISPENSER AN/ALE-29A
- 7.39 HYBRID CO/AN
- 7.54 CHAFF & FLARE DISPENSER CUT OFF SWITCH
- 7.55 ECM SYS INTERFACE ADAPTER

9.00 DISPLAYS

- 9.12 CONVERTER VDIG
- 9.22 CONTROL PWR SUPPLY INDIC GROUP ASA-79

10.00 ELECTRICAL POWER SYSTEM

- 10.03 GEN CONTROL UNIT (2)
- 10.06 100 AMP TRANS/RECT (2)
- 10.20 EMERGENCY GEN 5KVA+50A DC
- 10.21 EMERGENCY GEN CONTROL UNIT
- 10.30 GROUND POWER MONITOR

11.00 AUXILIARY SYSTEMS

- 11.71 ICE-DET TURB AIR IN
- 11.76 CONTROL UNIT (FIRE DETECTION)(2)
- 11.83 MACH LEVER (CONTROL UNIT)
- 11.85 PROGRAMMER INLET CONTROL
- 11.86 PROBE ANGLE OF ATTACK
- 11.87 SENSOR TOT PRESS
- 11.91 CONTROLLER CONT. SET MANEUVER
- 11.24 MULTI CHANNEL DIMMER CONTROL

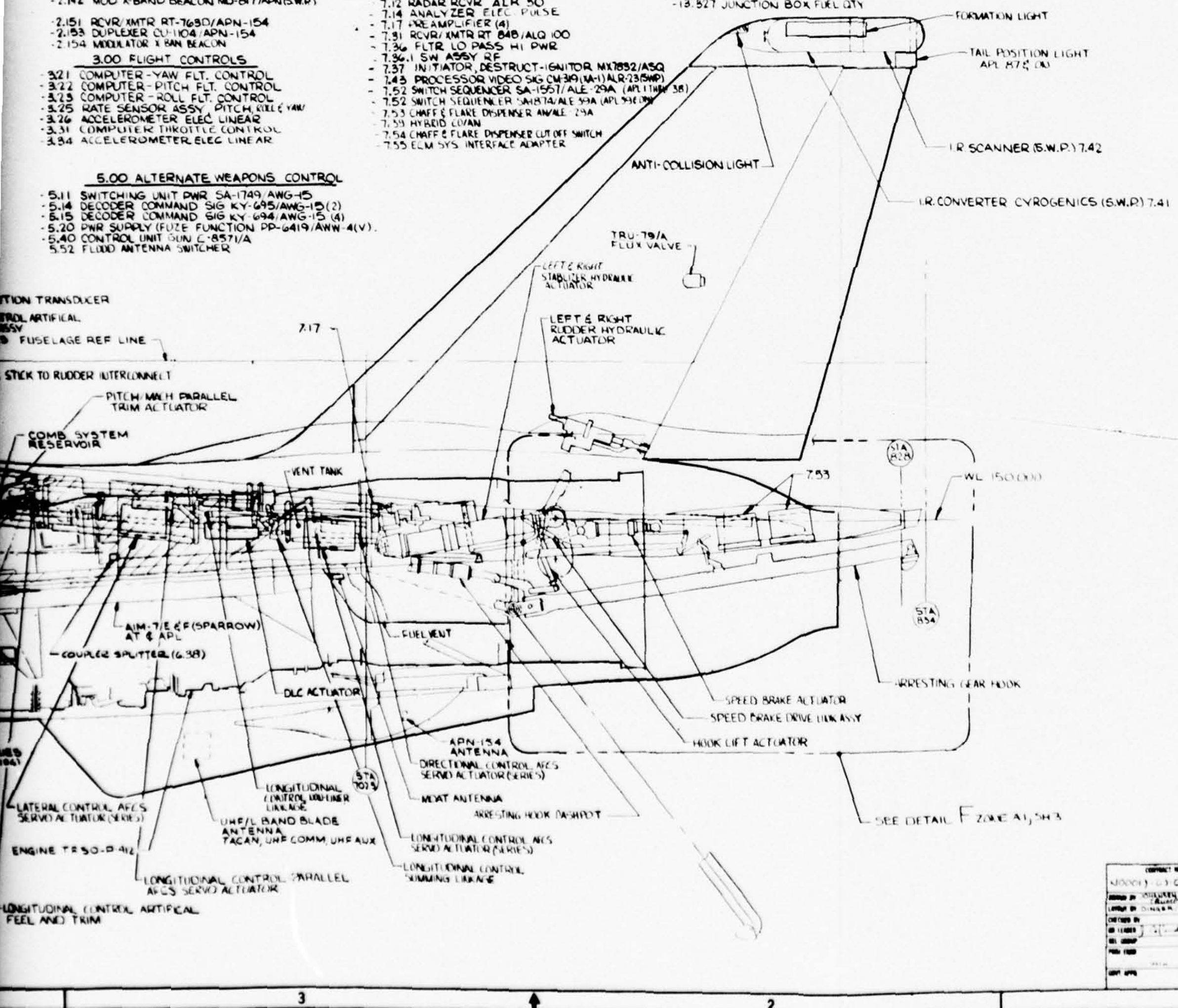
12.00 CIRCUIT BRKR PANELS

- 12.210 CONTACTOR, WG SWP BACK UP
- 12.212 CONTACTOR, OUTBD SPOILER

13.00 INSTRUMENTS

- 13.12 XMTR TRU 145A
- 13.31 PROBE TOTAL TEMP
- 13.41 INDICATOR, COUNTING MS25448-1(3)
- 13.42 TRANSDUCER MS25447-7 (3)
- 13.43 NORMAL ACCELEROMETER XMTR
- 13.70 PITOT TUBE DUAL ST
- 13.91 TRU-2A/A TRAN. RATE GYRO
- 13.121 N. CONVERTER
- 13.132 POWER SUPPLY - FUEL FLOW XMTR
- 13.312 CRU-23/A DUMMY CONVERTER
- 13.323 LOW LEVEL SENSING (2)
- 13.324 CONV SIG DATA
- 13.327 JUNCTION BOX FUEL QTY

LTR	DESCRIPTION
C	REVISED DWG PER NAVY REVIEW
D	REVISED DRAWING REINSTATED APX-76 SYSTEM & REVISED CONFIGURATION TO AGREE
E	REVISED DRAWING PER LATEST CONFIGURATION
F	REVISED DRAWING PER LATEST EQUIPMENT CONFIGURATION REQUIREMENTS. RELOCATED CHAFF & FLARE DISP AN/ALE 29 TO AFT CENTER BODY STA 777.
G	REVISED DRAWING PER LATEST EQUIPMENT CONFIG
H	REVISED DRAWING PER LATEST EQUIPMENT CONFIG.
J	REVISED DRAWING PER LATEST EQUIPMENT CONFIG
K	REVISED DRAWING PER LATEST EQUIPMENT CONFIG
L	REVISE DRAWING PER LATEST EQUIPMENT CONFIG
M	REVISE DRAWING PER LATEST EQUIPMENT CONFIG



GRUMMAN AIRCRAFT ENGINEERING CORPORATION BETHPAGE NEW YORK 11714

INBOARD PROFILE F-14A

J 26512 A51F0911 M

A51F0911

Figure 41. Inboard Profile, LH Side

Finding a location for an MMD in the rear cockpit is yet unresolved. The Caution Advisory Indicator in the rear cockpit is considerably smaller than the one in the front cockpit. Therefore, its removal leaves very little space to work with in the way of locating the MMD. Also, on either the left or right side console there is not sufficient unused space to mount an MMD. Creation of the required space in either console would involve moving several panels from one side to the other. Because of this problem, the following possible solutions exist for resolving the MMD problem in the NFO's cockpit:

- Use of the Tactical Information Display (TID), or ECM Display to display MMD information in the rear cockpit. The main disadvantage to this approach is that it would require redesign of whichever of these displays is used. Such a redesign is undesirable due to development cost and is not recommended.

- Make the necessary moves on existing equipment as required to provide sufficient space to mount the MMD in the NFO's left or right side console. The disadvantage of this approach is that complex aircraft wiring changes would be required to keep associated equipment together. Considerable cost would be incurred in pursuing this approach.

- Incorporate the display functions of the Digital Data Indicator (DDI) into the NFO's MMD. The DDI would then be eliminated in the outboard right side console. The ECM Display Control Panel would be moved from the inboard right side console to the space formerly occupied by the DDI. The space vacated by the ECM Display Control Panel would be enlarged by moving the remaining three pieces of equipment in the inboard right side console approximately six inches toward the rear of the console. This would provide sufficient space in the inboard right side console for mounting the MMD. This disadvantages of this approach follow:

  a. Display requirements for the MMD and the DDI are such that the CRT display would have to be partitioned to accommodate both displays. This could be accomplished but would require more sophisticated software and circuitry. In addition, the display capability would be reduced for the MMD, resulting in messages averaging more pages per message.

  b. The DDI essentially provides mission-oriented information for the NFO. The nine data link carrier landing related messages appearing on the DDI are repeated for the pilot on legends that are located on the pilot's Vertical Display Indicator. The disadvantage here is that circuits and associated software will have to be incorporated in the pilot's MMD to provide for these data link messages.

- Leave the NFO's cockpit as is. This would mean that an MMD would not be installed in the rear cockpit. The NFO would use the existing fault indications.

This approach would permit development and flight evaluation of an MMD (pilot's cockpit) with the least expense and impact to the F-14 Program and is the recommended approach.

Multiplex vs Discrete Wiring

Due to the number of input signals involved (≈ 60), the advantages of the use of multiplex techniques, as opposed to the present discrete wiring as a means of getting the various input signal information to the MMD, was considered. Multiplexing involves linking all of the fault sensors in the aircraft to a data bus by means of Standard Interface Units (SIU's). These would perform sensor address detection from the address word on the data bus, sampling of the addressed sensor, and placement of information on the data bus in digital format, for use by the MMD microcomputer. Figure 42 is a diagram of the Standard Interface Unit. The SIU's would be located as near as practical to the sensors to reduce the amount of discrete wiring to a minimum. The MMD microcomputer would then program the sampling of each sensor in sequence, and store the status information in memory. When a fault is detected, the microcomputer would initiate the required display. In this manner, the status of each input is repeatedly sampled and the memory updated. The number of wires entering the cockpit for use by the MMD is reduced to those required for the data bus, the control signals and power for the MMD. In this case, multiplexing as opposed to discrete wiring, results in a wiring reduction of approximately 90%.

Undoubtedly, if we were designing a new aircraft with an MMD, multiplexing would be the best approach. This would greatly simplify MMD design because in addition to the interface wiring reduction, all incoming information would be in the same (digital) format. In the case of the F-14, the aircraft is already designed and built. The advantage of reducing the number of wires entering the cockpit is offset by the fact that these wires are already there. The advantage of interface simplicity as a result of having the same format for all incoming data is also offset by the need to link the various sensors to a data bus through SIU's. At this stage, such a change would have a major impact on the aircraft wiring, equipment lines, drawings, and maintenance and technical manuals. In addition, there would be a question of decreased overall reliability because of the rework, and probably some degree of additional qualification testing would be required. Such an approach would seem impractical for an MMD evaluation project. However, for new aircraft designs, or for production major modification efforts, multiplexing would offer many advantages.

Threat (DECM) Indication

Present production F-14's have the following DECM warning indication for the pilot:

SA TRK

AI

AI/AAA

SAM

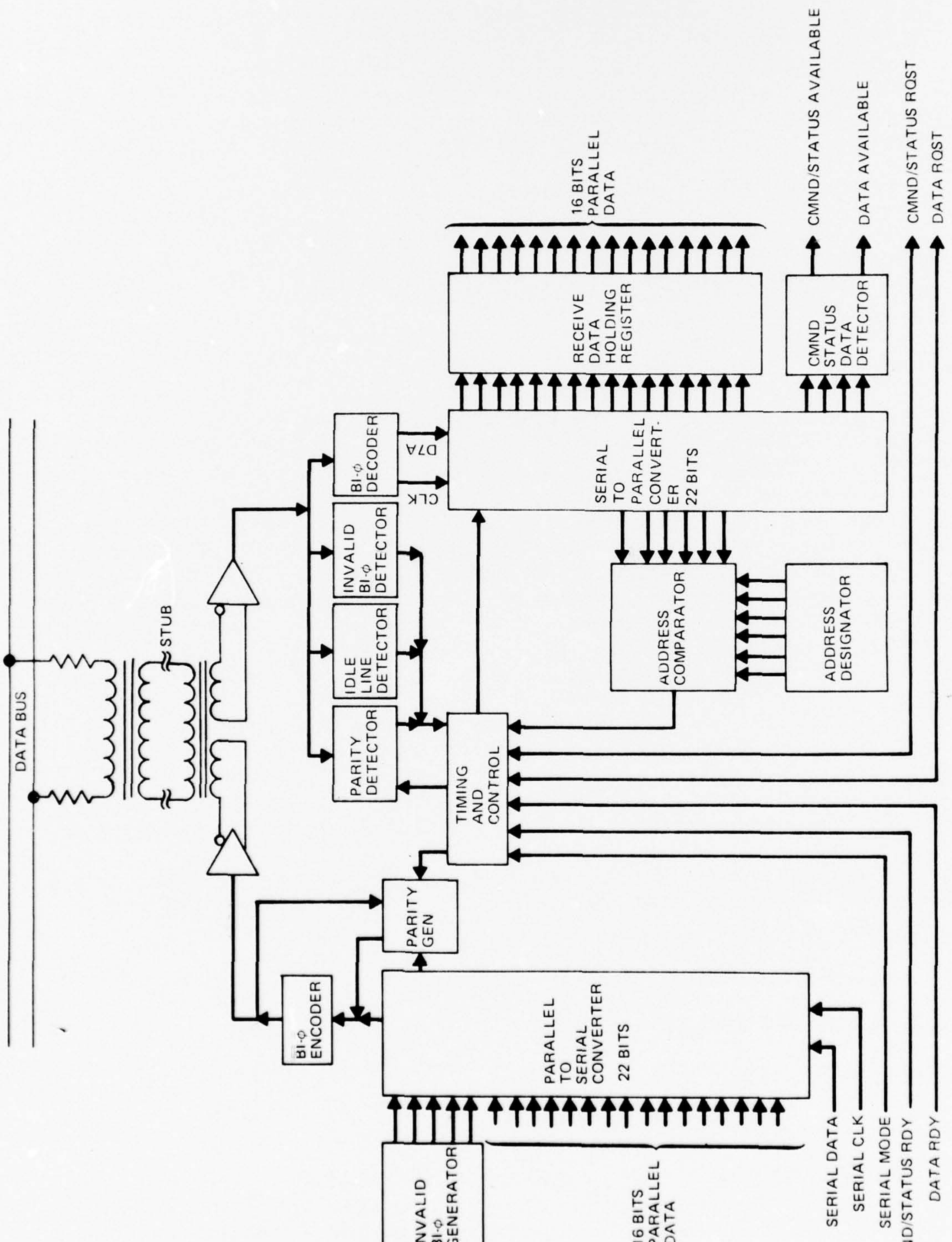


Figure 42. Standard Interface Unit

Because these are dedicated warning indications, Grumman recommends they be retained along with the other dedicated warning indications. These are indications of the existence of various types of threats. These indications are crucial and being warnings, are located within the pilot's 30^{o} cone of vision, providing heads-up indication. In some cases there is an accompanying aural signal. These indications could be displayed on the MMD without any difficulty. However, at the time when these indications are likely to occur, an additional (redundant) warning indication on the MMD would be counter - productive because it would increase the work load for the pilot during a very critical part of a mission. The need for displaying a course of action for these indications is also of questionable value. If the pilot does not know what to do, and automatically take the appropriate action, he is in serious trouble. For these reasons it is strongly recommended that these DECM indications not be displayed on the MMD.

Fault Indications Prior to Engine Start

Prior to engine start, the following fault indications exist in the F-14; L & R Generator, L & R Fuel Pressure, Oil Pressure, Hydraulic Pressure, IMU, Navigation Computer, Ladder, Wing Sweep (advisory), and Wing Sweep (warning). These indications represent normal conditions since at this time the corresponding systems are not operating. As the engine start sequence progresses, and the various systems become operative, these apparent fault indications will disappear. For the proposed MMD, these indications include a mix of caution, and warning indications. Therefore, in keeping with normal operation, the warning (Wing Sweep) would have priority and accordingly would be displayed on the MMD along with the course of action. The other apparent faults would not be displayed until the warning message is cancelled. Therefore, until the warning message is cancelled, the MMD would be tied up with a meaningless message. This problem will be avoided by the use of appropriate gating to preclude the MMD sensing the no go conditions on these lines as faults. When the no go condition should be gone, the inputs will be reactivated. For example, the ladder input signal will be gated with an external power discrete. By the time external power is removed, the ladder should be in the stowed position. If it is not, the proper fault indication "ladder unlatched" will be indicated on the MMD.

An "engine running" discrete will be generated from each engine tachometer generator for 50% rpm. These discretes will then be used to gate the following input signals:

- L & R Generator
- L & R Oil Pressure
- L & R Fuel Pressure
- Flight and Combined Hydraulic Pressure

Using this type of gating all of these apparent faults would be inhibited when they should not be indicated, but the inhibitions will be removed in time to allow proper fault indication when the engines are running and the systems involved are operating. In this manner, the pilot is not bothered with false indications, which have to be watched to see if they go away at the right time as is the case with the present CAI.

ADDITIONAL HARDWARE REQUIREMENTS

The existing CAI contains several circuits used primarily for purposes external to the CAI. These include a flasher circuit, dimming circuits, provisions for testing externally located indicators, a pair of external power supplies, and certain discrete circuits which drive indicators remotely located from the CAI. The purpose of each of this circuits is as follows:

1. The flasher circuit is used to meet the flash and drive requirements and drive for the MC and Wheels warning indicators.

2. The dimming circuit, upon receipt of a discrete signal, reduces the output voltage of the circuits that drive external indicators. This is required to meet indicator maximum brightness requirements during dim conditions.

3. The test provisions essentially cause the test input of each CAI discrete circuit to be activated whenever an active test signal is present at the interface. This results in all indications being illuminated at the same time while the test signal is present.

4. The two external drive busses each have a capability of 1.5 amp (incandescent load) and are used throughout the cockpit to provide dimmable supplies for various indicators.

In addition, the CAI contains certain discrete circuits that operate remotely located lamp indicators. These are Reduce Speed, Altitude Low, Auto Throttle, A/P Ref, and Wheels. Altitude Low, however, is no longer used and Auto Throttle is now implemented without interfacing the CAI. Therefore, with the replacement of the CAI in the pilots cockpit with an MMD, the above mentioned features would have to be added someplace in the aircraft. The recommended approach is to include these in the MMD Electronics Unit. Accordingly, these provisions have been included in the MMD power estimate of 500 watts.

RECOMMENDATIONS

In conducting this study, several areas have been uncovered which should be investigated further:

1. Conceptual. (Requirements) studies:

   a. MMD/EMD - This would investigate the feasibility of making the MMD and the Engine Monitor Displays identical, so that these functions could be combined into a single display, or the functions kept separate should one of these dual redundant displays fail. The investigation would determine what parameters should be displayed and how, as well as processing and sizing.

   b. V/STOL - Determine what impact V/STOL will have on the MMD.

c. Advisories of HYCOS, Engine Fatigue, and Fuel Management, as added capabilities to the MMD. Trade-off against alternative configurations.

d. Display of Mission/Tactics information, including degraded modes.

e. Display of WRA/SRA maintenance information using information from other systems internal BITE.

f. Systems level preflight checklist and postflight maintenance test instructions.

g. Use of similar hardware (MMD) for armament display.

2. Man-Machine Evaluation

a. Static/Dynamic simulation including flight controls and realistic aircraft responses.

b. AIDS formats in V/STOL mode. This would include pilot performance during takeoff and landing.

c. Cockpit geometry will include HUD Field-of-view, exit pupil constraints, etc.

d. Determination of required update rates.

e. Viewable area and symbology size to prevent clutter.

f. Capacitance tough-type switches should be evaluated.

3. Prototype Development - Develop a prototype of proposed MMD. The development cost is estimated to be approximately $500K.

4. Flight Test - Evaluate concept in an F-14. The MMD recommended in this report has many advantages over the existing CAI, and is believed to represent the least expensive approach to the development and flight evaluation of an MMD.

The evaluations and studies listed above are very valuable because they often uncover unforeseen problem areas. They also allow the best solution to a given problem to be determined before funds are committed to design and/or hardware. The knowledge gained will result in more practical designs, elimination of costly redesigns, and as a result, provide on time deliveries at minimum cost.

Appendix A

MASTER MONITOR DISPLAY SPECIFICATION FOR THE F-14

The following paragraphs define those requirements specific to the Master Monitor Display (MMD) and together with the Avionic Boilerplate Specification, F-14A-BP-68-1K, form the Design Control Specification for the MMD. The paragraphs are numbered to indicate the appropriate place of substitution into the Avionic Boilerplate Specification in order to form the Design Control Specification for the MMD.

1.1 Scope - This specification covers the design, construction, performance and testing for the Master Monitor Display (MMD) for use on the F-14 Weapon System.

1.2

Title	Type Designation (AN)
Display, Master Monitor	TBD

2.1.2 Drawings

GAC: A51A TBD

Figures A-1 through A-3 are intended to indicate the tentative form factor of the Display Unit of the MMD. An electronics unit of dimensions 4 x 7 x 9 inches, is part of the MMD but will be located remotely from the display unit in the aircraft.

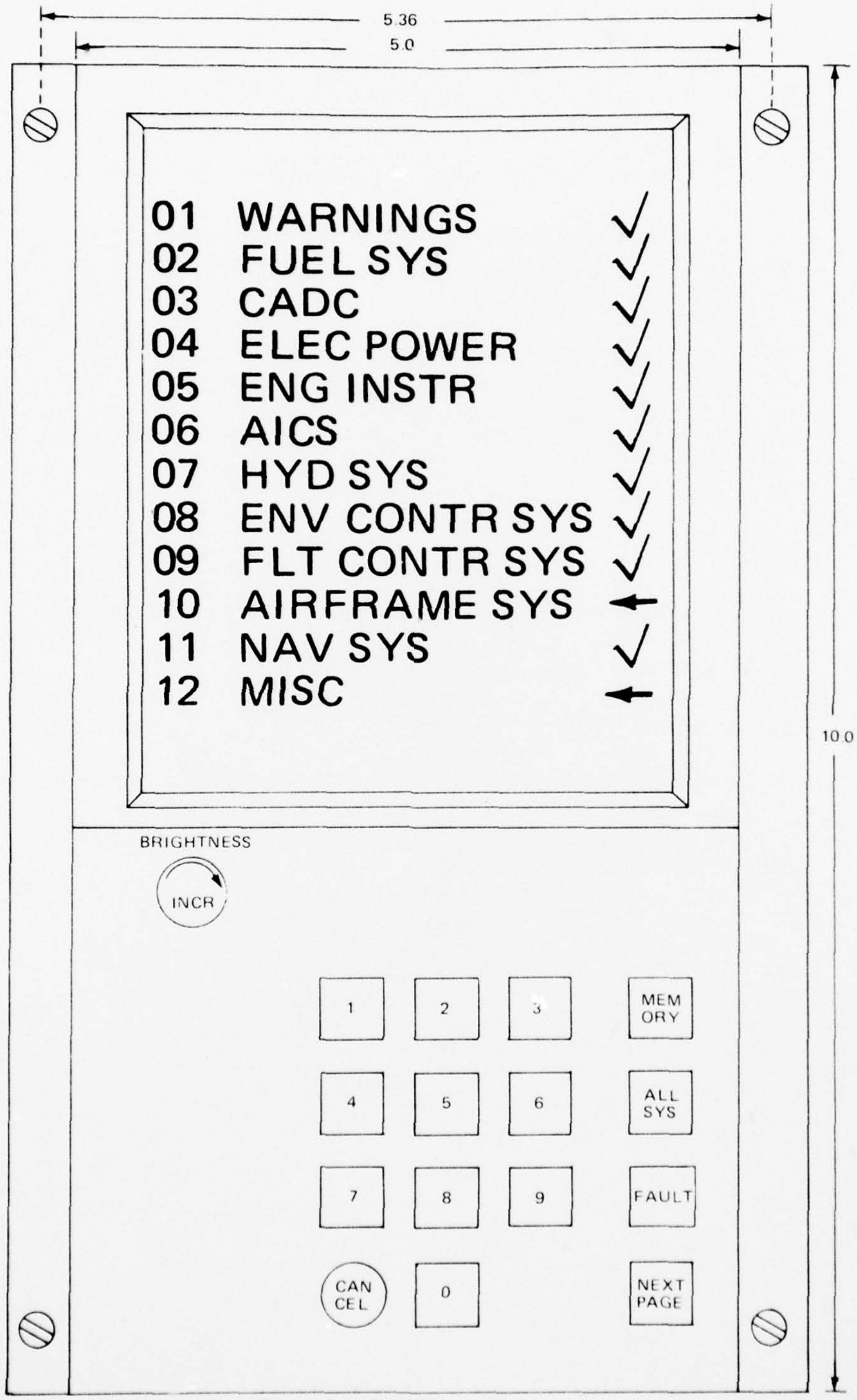


Figure A-1 MMD Front Face

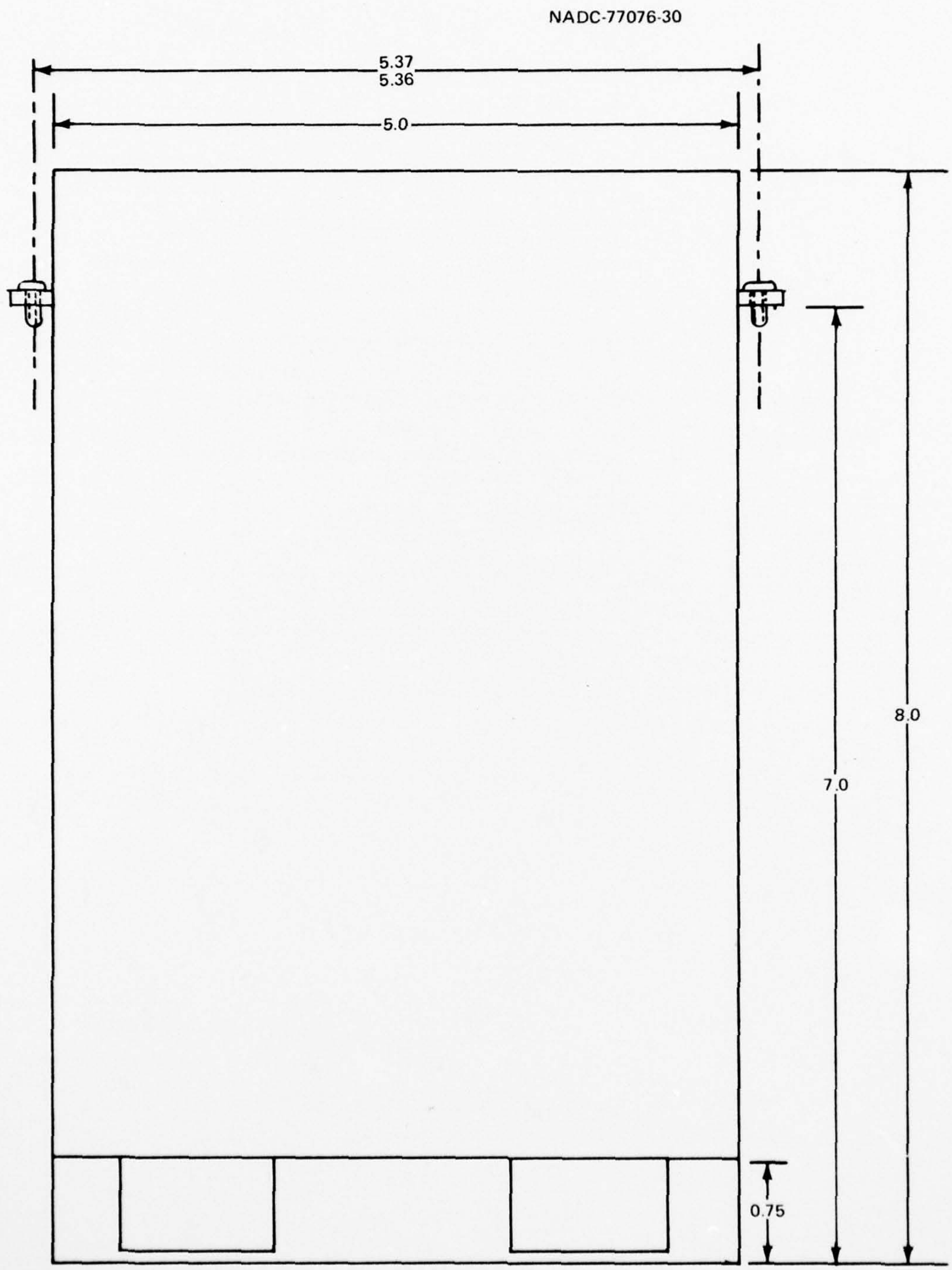


Figure A-2 MMD Outline Dimensional Drawing (End View)

NADC-77076-30

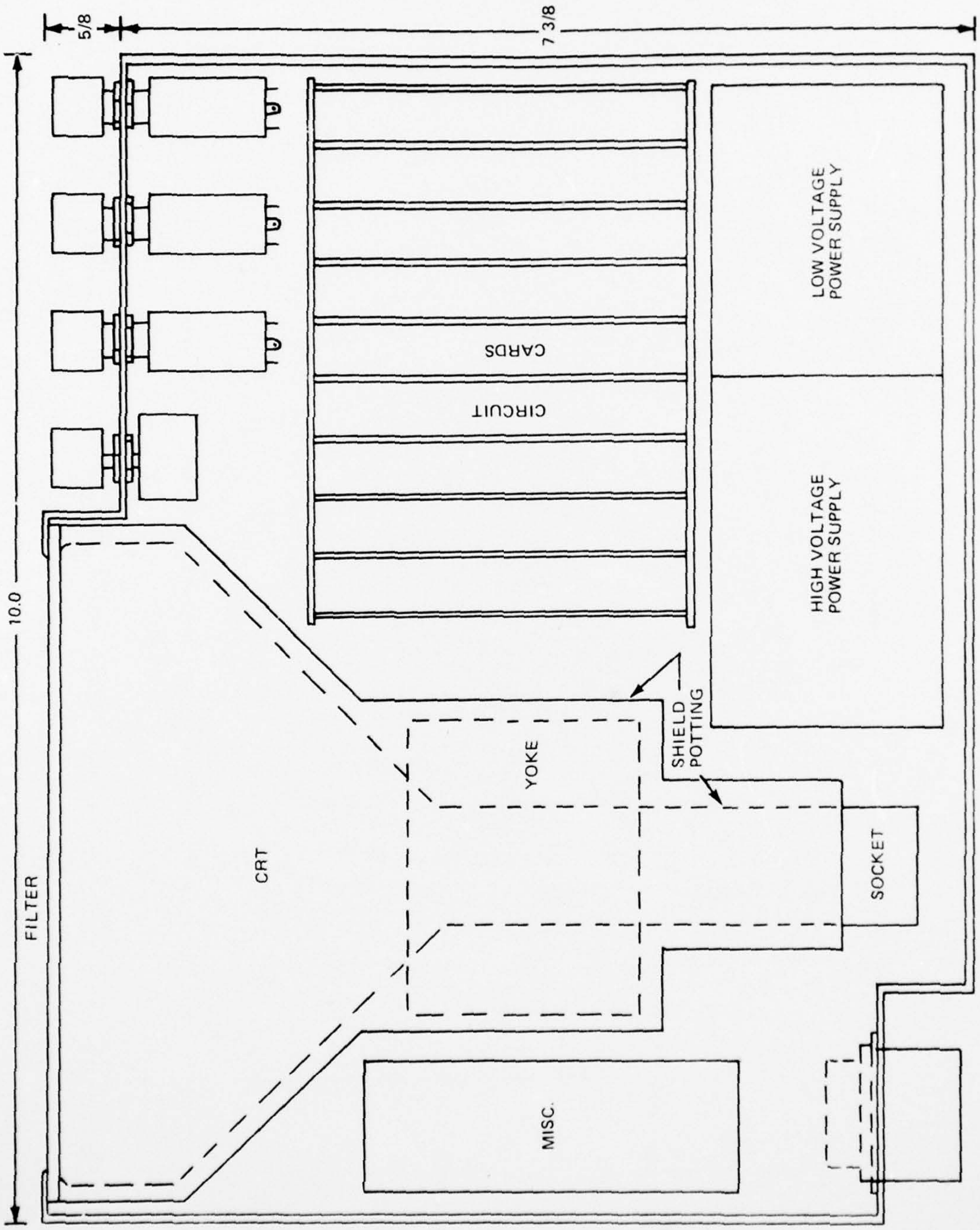


Figure A-3 MMD Cutaway Side View

MMD SPECIFICATION

3.4 Performance. Unless otherwise specified, values set forth to establish the requirements for satisfactory performance apply to performance under both standard and environmental service conditions. When reduced performance under the environmental conditions is acceptable, tolerances or values setting forth acceptable variations from the performance under the standard conditions will be specified.

3.4.1 Master Monitor Display. The Master Monitor Display (MMD) shall perform the following under the conditions specified.

NOTE: The Master Caution (MC) light referred to in the steps which follow shall be located on the Master Caution Assembly which is independent of the MMD and shall contain a reset switch which when depressed by the pilot shall cause the master caution line to be de-energized.

3.5 Detail Requirements

3.5.1 Modes of Operation

3.5.1.1 *Normal* - *Automatic display of fault and course of action for faults of the warning or caution categories.*

(1) Detection of a fault condition on a warning input shall cause the following:

(a) Display on the MMD of the warning fault and the prescribed course of action for the fault.

(2) Detection of a fault condition on a caution input shall cause the following:

(a) Master Caution Indication

(b) Display on the MMD of the caution fault and the prescribed course of action for the fault.

(3) The fault (Heading) portion of the display shall cancel automatically when the fault no longer exists. The course of action portion will be cancelled manually by use of the cancel push-button.

3.5.1.2 Manual Mode

3.5.1.2.1 Means shall be provided to allow manual selection of the following displays:

- Complete Systems Status indicating total status on a system basis.

  (1) Checks (✓) shall be used to indicate the status of all systems or subsystems which contain no fault.

  (2) Arrows (←) shall be used to indicate the status of all systems or subsystems which contain at least one fault.

- Display of a selected system indicating the status of each subsystem comprising the selected system.

- Display of all faults contained in a selected system with the respective courses of action.

- Display of fault history during a mission. This storage shall be non volatile for power interruptions.

3.5.1.2.2 Systems selection shall be achieved by depression of the appropriate keyboard digits to match the desired system number. (Ref: Table A-2)

3.5.1.2.3 Means shall be provided to cancel a display when it is no longer desired. However, in the event of warning faults only the course of action portion can be cancelled. Warning faults remain as long as the fault remains.

3.5.1.2.4 Means shall be provided to cause the display of the next page of messages which, due to length, require several pages for display of the complete message. For such messages, any page shall be selectable by continued depressions of the next page pushbutton, including recycling back to page one after last page of text.

3.5.1.3 Test Mode

Means shall be provided to self-test the MMD upon receipt of an external signal as follows:

ON (Test)	+28VDC, 100 ma max.
OFF (Not Test)	Open Circuit

3.5.1.4 Display Priority

3.5.1.4.1 Display of faults of the warning category (highest priority) shall have priority over all other fault category displays.

3.5.1.4.2 Display of faults of the caution category shall have priority over advisory fault category displays.

3.5.1.4.3 In event of display conflict, the display having the higher priority shall prevail. The other(s) shall be displayed automatically when the higher priority fault display is cancelled.

3.5.1.4.4 Automatic displays resulting from fault detection shall prevail in any conflict with manually selected displays.

3.5.1.4.5 The simultaneous occurrence of two or more faults of the same fault category, shall cause a preview summary listing of these faults without course of action information, below which, each fault with course of action information shall be displayed in page format according to the provision of this specification.

3.5.1.4.6 A fault of the same priority occurring while a fault message is displayed, shall result in the new fault being added to the display in the first line which shall be reserved for this purpose and for the display of unremoved warning faults. The new message consisting of fault and course of action shall be displayed automatically when the existing display is cancelled.

3.5.2 MMD Inputs

3.5.2.1 The MMD input signal lines listed in (c) shall indicate either of two states listed in (a) and (b) below:

(a) Fault (active state) - +28VDC, 10 ma max as defined by MIL-STD-704, Category B.

(b) No fault (inactive state) - Open Circuit

(c)

Brakes (W)*	Trans/Rect (C)	WSHLD HOT (C)
Bingo (C)	Wheels (W)	ARI Engaged (C)
Bleed Duct (C)	L (R) Inlet (C)	Cabin Press (C)
Canopy (C)	Inlet Ice (C)	Flt Hyd Press (C)
L (R) Fire (W)	Ladder (C)	Comb Hyd Press (C)
L (R) Fuel Low (C)	Launch Bar (C)	Asym FL/SL Lock-out (C)
L (R) Fuel Press (C)	L (R) Ramps (C)	L (R) Oil Hot (C)
L (R) Gen (C)	L (R) N_1 OVSP (C)	
Oxy Low (C)	L (R) Start Valve (C)	

----

*(W) signifies warning, (C) signifies caution

3.5.2.2 The MMD input signal lines listed in (c) shall indicate either of two states listed in (a) and (b).

(a) No Fault (inactive state): Open Circuit

(b) Fault (active state): Ground (A/C)

(c)

ACLS/AP (C)*	Integ Trim (C)	L(R) Oil Press (C)
AHRS (C)	Nav Comp (C)	
Auto Throt (C)	NWS Enga (C)	

3.5.2.3 The MMD input signal lines listed in (c) shall indicate either of two states as defined in (a) and (b):

(a) No fault (inactive state): $+4.5 \pm 0.5$ VDC

Source impedance: Less than 100 ohms

(b) Fault (active state): 0.0 (+0.5, -0.0) VDC

Source impedance: can vary from short circuit (zero ohms) to an open circuit.

(c)

Auto Pilot (C)*	Pitch Stab 1 (C)	Mach Trim (C)
A/P Ref (C)	Pitch Stab 2 (C)	Yaw Stab Op (C)
Roll Stab 1 (C)	Rudder Auth (C)	Yaw Stab Out (C)
Roll Stab 2 (C)	Spoilers (C)	HZ Tail Auth (C)

3.5.2.4 The MMD input signal lines listed in (c) shall indicate either of two states as defined in (a) and (b):

(a) No Fault (inactive state): Saturated Transistor (less than 0.4 VDC) 10 ma sink.

(b) Fault (active state): Open (cut-off transistor) 25 microamp max. leakage current.

(c) CADC (C)*

Glove Vane (C)

Flaps (C)

Reduce Speed (W)

3.5.2.5 The MMD input signal lines listed in (c) shall indicate either of two states as defined in (a) and (b):

(a) No fault (inactive state): Ground (A/C)

(b) Fault (active state): Open circuit

(c) IMU (C)

Wing Sweep (C)

3.5.2.6 The MMD input lines listed in (c) shall indicate either of two states as defined in (a) and (b) for two separate inputs:

Input 1

(a) No fault (Inactive state): Saturated transistor to ground (less than 0.4 VDC)

(b) Fault (active state): Open (cut-off transistor) 25 microamps max leakage current

Input 2

(a) No fault (inactive state): A/C ground } through switch contacts

(b) Fault (active state): Open } through switch contacts

(c) Wing Sweep (W)

3.5.2.7 Additional Input Signals

3.5.2.7.1 Dimming - One line: An external signal shall be supplied to define normal/dim light conditions as follows:

(1) Normal: Open Circuit

(2) Dim: +28VDC, 100 ma max per MIL-STD 704 Cat B

3.5.2.7.2 Test - One Line: An external signal shall be supplied to define the ON/OFF Test Mode as follows:

ON (Test): +28VDC, 100 ma max per MIL-STD-704, Cat B

OFF (Not Test): Open Circuit

3.5.2.7.3 Master Caution Reset - One Line: An external signal shall be supplied to define the master caution reset function as follows:

Normal: Open Circuit

Reset: A/C Ground, 10 ma max

3.5.2.7.4 Input Source Fault Isolation - Loss of any electrical signal due to an open or short to ground on an input shall not cause any component, assembly, or subassembly to fail, or cause a degradation in the performance regardless of the mode or length of time that the input signal is missing from the display equipment. Input signals directly derived from a power source shall be protected from damage due to transients present on the power source.

3.5.3 MMD Outputs

3.5.3.1 MMD Outputs are defined in Table I and shall be displayed according to the provisions of Sections 3.4 and 3.5 of this specification. Display shall show fault and the prescribed course of action in page format. In event several pages are required to complete the message, this shall be indicated by use of the caption "Cont'd Next Page" at the bottom of each page as appropriate. Each page of a message shall indicate the fault portion of the message within the requirements of Para. 3.5.1.1(3).

3.5.3.2 Display Characteristics

Visibility, legibility, character size and spacing, and line spacing shall conform to MIL-STD-1472B.

3.5.3.3 Switching Time - The switching time shall be no greater than 750 milliseconds to switch to (or from) one stabilized mode to another after a discrete switching signal is received.

3.5.3.4 Brightness Control - A manual brightness control shall be provided. CW rotation shall provide increased brightness.

3.5.3.5 Display Operation Under Power Transients - The display equipment shall automatically return to full operation as specified herein within 1.0 second after complete loss of aircraft power for up to 50 msec. maximum.

3.5.3.5.1 Display Operation Under Power Transients - The display equipment shall meet the requirements of this specification when operating within the normal electrical system transient environment caused by load switching, etc.

3.5.3.6 Display Noise - No noise shall appear on the display CRT at any brightness or contrast level when the input Z axis terminals of the indicator are bridged by the normal input impedance and no video signals are applied.

3.5.3.7 Protection Circuits - The CRT shall be protected from burn spots due to loss of sweeps or loss of critical power supply voltages. Secondary failure of the phosphor shall be prevented when any other primary circuit failure occurs. Special phosphor protect circuitry shall be incorporated in the equipment to prevent excessive phosphor element dwell time which would cause phosphor burn. The High Voltage Power Supply shall be protected against transient arc over at the CRT.

3.5.3.8 CRT Controls - There shall be no need for any remote CRT controls accessible to the display operator during normal operations except brightness.

3.5.3.9 Alignments/Adjustments - The equipment shall meet the requirements with the replacement of any assembly/subassembly without alignments/adjustments except those display controls defined in this specification.

3.5.3.10 Subassembly Failure Modes - No subassembly of this MMD shall cause a secondary failure of another subassembly of this system in the event of its failure. CRT arcing, while a normal operational condition, shall not cause secondary failures of assemblies or subassemblies nor shall the arc cause transients to be propogated beyond the CRT subassembly. Normal operation shall resume automatically with no loss in equipment reliability upon cessation of the arc.

3.5.3.11 Display Size - Each indicator shall provide a CRT display with a usable viewing area of 4 inches by 5 inches ± 10%.

3.5.3.12 Brightness - Display brightness shall be continuously variable, by use of the manual brightness control, from maximum CRT brightness to barely perceptible under complete ambient black-out conditions. The indicator (with the day filter installed) shall produce a display of such brightness that all symbols will be easily discernible under a natural daylight ambient illumination of 12,000 ft- Lamberts without the aid of hood or shade. All brightness/contrast readings shall be measured with a standard spot photometer with the display being operated in the normal scan rates and size as specified herein. Phosphor type and color shall be approved by the Contracting Agency.

3.5.3.13 Cathode Ray Tube - Cathode ray tube (s) (CRTs) used as components of the display unit shall be high-intensity/high resolution CRTs with the following characteristics:

(a) Phosphor - the phosphor shall be chosen on the basis of optimum clarity and contrast for the projected display. In choosing the phosphor, consideration should be given to spectral distribution of the fluorescence and phosphorescence, persistence, background and image brightness, and sensitivity of the phosphor to burn at operating voltage and operating cycle time. Selection shall be such as to meet all brightness, contrast and resolution requirements specified herein as well as the spectral requirements of both day and night filters.

(b) Persistence - Tube persistence shall be such that neither stickiness or flicker of the display shall be perceptible to a normal human eye directly or under peripheral vision at conditions of bright daylight or night ambient illumination.

(c) Burn Spots - Criteria for CRT burn spots shall be as follows:

(1) Browning of Phosphor - If tube passes light output requirements of the Acceptance Test procedures at the four points deemed most browned by the display of fixed symbology or age, it is acceptable.

(2) If the tube has the following quantity of burn spots, or less, it is acceptable; (burn ideally should be measured with tube off).

(a) Five (5) or less non-elongated spots on the CRT which are between 0.010 and 0.015 inches in diameter with greater than 0.25 inch separation will be acceptable.

Non-elongated spots/elongated spots (lines) whose diameters/widths are less than 0.010 inches on the CRT are acceptable (no limit on quantity).

(b) Elongated burn spots/lines which are less than 0.010 inches wide on the CRT are acceptable (no limit on quantity).

(c) Elongated burn spots/lines up to 0.015 inches wide, and a maximum of 0.250 inches long are acceptable providing that there are no more than (1) on the CRT.

(d) Elongated burn spots/lines greater than 0.015 inches wide and 0.250 inches long are not acceptable.

(d) Magnetic Shielding - A suitable MU-metal or equivalent magnetic shield should be installed around each CRT to prevent deflection of the electron beam due to magnetic fields caused by the Earth's magnetic effect or by other electrical equipment in the aircraft.

3.5.3.14 A suitable filter (day filter) shall be incorporated over the CRT face to enhance the contrast ratio and permit readability under conditions of high ambient lighting.

3.5.4 Physical Requirements

3.5.4.1 Overall dimensions shall not exceed:

Display Unit

Length	10 inches
Width	5 3/4 inches
Depth	8 inches
Weight	TBD (Max at this time appears to be 12 lbs)

Electronics Unit

Length	9 inches
Width	7 inches
Depth	4 inches
Weight	10 pounds max

Total power for both units will be approximately 300 watts.

(Tables A-1 and A-2 follow and form part of this Specification)

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Outputs \ MMD Inputs	ACLS/AP	AHRS	Auto Pilot	Auto Throttle	Brakes	A/P Ref	Bingo	Bleed Duct	CADC	Canopy	L(R) Fire
Inactive	OC	OC	4.5 vdc	OC	OC	4.5 vdc	OC	OC	Sat. Trans	OC	OC
Active	Gnd	Gnd A/C	O vdc	Gnd	26 vdc	OC	28 vdc	28 vdc	Cutoff Trans	28 vdc	28 vdc
Remote Warning Indication					X						X
Master Caution	X	X	X	X		X	X	X	X	X	
ACLS/AP Disengaged	X										
1. Take Control - Land Manually											
AHRS/Compass Controller Failure		X									
1. Use INS-IMU											
2. Avoid IFR Flt if INS-IMU not Avail.											
Auto Pilot Failure			X								
1. Check A/P Mode Failure											
2. Recycle A/P Engage											
Auto Throttle Disengaged				X							
1. Assume Manual/Boost Control											
2. Satisfy APC Interlocks											
3. Reengage APC Auto											
Brakes					X						
1. Anti Skid - Off											
2. Caution-Modulate Brakes											
3. Release Emergency Brake											
A/P Ref Not Engaged						X					
1. Depress Ref Engage Button											
Bingo							X				
1. Fuel Remaining is Reqd to Return to Base											
Bleed Duct								X			
1. Air Source - Off											
2. Ram Air-Increase (< 300 KIAS/0.8 IMN)											
3. Land-ASAP											
CADC Failure									X		
1. Master Reset-Depress – If Fault Remains											
2. Remain Below 1.5 IMN											
Canopy Unlocked										X	
1. Canopy Handle-Boost Close											
2. Visors/Seats-Down											
3. Stay Below 200 KIAS/15,000 Ft											
4. Land ASAP											
L(R) Fire											X
1. Throttle Affected Engine - Idle											
2. Air Source - Off											
3. If Fault Goes Away-Check Fire Det Sys *If Fault Remains or Fails Fire Det Test:*											
4. Throttle Affected Engine-Off											
5. Fuel Shutoff Affected Engine/Pull											
6. Land ASAP											
7. If Fire Persists - Eject											

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	L Fuel Low	R Fuel Low	L Fuel Press.	R Fuel Press.	L Gen	R Gen	Glove Vane	Oxy Low	Hz Tail Auth
Inactive	OC	OC	OC	OC	OC	OC	Sat. Trans	OC	4.5 vdc
Active	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	Cutoff Trans	28 vdc	0 vdc
Remote Warning Indication	X	X	X	X	X	X	X	X	X
Master Caution									
L(R) Fuel Low	X	X							
1. Dump Switch-off									
2. Fuel Distribution-Check-Balance									
If Wing/Ext Fuel Remains:									
3. Wing/Ext Trans Switch-Oride									
L (R) Fuel Press.			X	X					
1. No A/B Above 15,000 Ft on Affected Engine									
2. Fuel Distribution-Monitor/Balance									
3. Land ASAP									
If BothL&R Faults Occur									
1. Descend to < 25,000 Ft									
2. *Maintain Cruise Power or Less*									
3. Land ASAP									
L (R) Gen Off Line					X	X			
1. Affected Gen-Off/Reset, Then Norm									
If Fault Remains:									
2. Affected Gen-Test									
Fault Goes Away-Distr Sys Problem									
Fault Remains-IDG/GCU Problem									
If Both L&R Gen Faults Occur									
1. Generators - Cycle									
If Temp Loss of Comb Press. Causes									
Emerg Gen to Drop Buss 2									
2. Emerg Gen-Cycle									
3. Land ASAP									
Glove Vane							X		
1. Check Hyd Pressure									
2. Maneuver Devices-Retract									
3. Master Reset-Depress									
Oxygen Low								X	
1. Cabin Alt < 10,000 Ft									
2. Mask-Off									
3. Oxy Switch - Off									
4. *Oxy and Mask on For Landing*									
HZ Tail Auth									X
1. Master Reset-Depress (10 Sec)									
2. > 400 KIAS, Restrict Lateral Control to ¼ Throw									
3. No Oversweep on Deck									

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Outputs \ MMD Inputs	Reduce Speed	Roll Stab. 1	Roll Stab. 2	Pitch Stab. 1	Pitch Stab. 2	Rudder Auth	Spoilers	Trans/Rect	Wheels
Inactive Sat. Trans	4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	4.5 vdc	OC	OC
Active Cutoff Trans	0 vdc	0 vdc	0 vdc	0 vdc	0 vdc	0 vdc	0 vdc	28 vdc	28 vdc
Remote Warning Indication	X								X
Master Caution		X	X	X	X	X	X	X	
MMD Fault & Course of Action									
Reduce Speed	X								
1. Decel to < 280 KIAS									
2. Check Flap Handle - 0°									
3. Master Reset - Depress - Then Repeat Cmd									
Roll/Pitch Stab. 1 or 2 Failure		X	X	X	X				
1. Cycle Appropriate Stab. Aug Sw									
No Corr Action or Limitations									
If Both 1 & 2 Roll/Pitch Stab. Faults Occur									
1. Airspeed - Decel to Stab. Limits									
Pitch - Not Restricted									
Roll - 0.93 IMN									
2. Wait 10 Sec for Self Test									
3. Recheck Faults									
If One Fault (1 or 2) Goes Away - Reset Stab Aug - No Limits									
If Both Faults (1 & 2) Remain,									
1. Leave Stab. Aug. - Off									
2. Stay Below Stab. Limits									
Warning: Do Not Engage ACLS or DLC									
Rudder Auth						X			
1. Reduce Airspeed - Use Caution in Rudder Deflection While at High Airspeed									
2. Master Reset - Depress 10 Sec									
3. If Fault Remains, Limit Rudder Above 250 KIAS to < 10°									
4. Landing - Possible Limited Rudder & NWS									
Spoilers							X		
1. Neutralize Lateral Control									
2. Master Reset - Depress									
If Fault Remains									
3. Avoide Abrupt Lateral Control & High Roll Rates									
Warning: With Wings Forward of 57°, Excessive Horiz Tail Differential May Cause Severe Structural Damage									
Trans/Rect Failure								X	
No Crew Action									
Wheels Not Down									X
Lower Landing Gear									

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	Integ Trim	L Inlet	R Inlet	INlet Ice	Ladder	Launch Bar	Mach Trim	Nav Comp	NWS Engaged	L Ramp	R Ramp
Inactive	OC	OC	OC	OC	OC	OC	4.5 vdc	OC	OC	OC	OC
Active	Gnd A/C	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	0 vdc	Gnd A/C	Gnd	28 vdc	28 vdc
Remote Warning Indication											
Master Caution	X	X	X	X	X	X	X	X	X	X	X
MMD Fault & Course of Action											
Integ Trim Failure - Use Manual Trim	X										
L (R) Inlet &/or L(R) Ramp		X	X							X	X
1. Decel to < 0.9 IMN											
2. Avoid Abrupt Throttle Movements											
3. Stow Affected Ramp											
4. Inlet Ramp-Auto											
If Ramp Fault Remains											
5. Check for Hyd Failure											
Note: Ramp Blow Back is Enhanced by Mil Power at 200 KIAS (Ramp 1) & by Idle at 0.85 IMN (Ramp 3) With Inlet Switch in Auto.											
6. Throttle (Bad Engine) - 80% or Less											
7. Land ASAP											
If ATTEMPTING AICS RESET (Inlet Fault Only)											
8. *Decel to < 0.5 IMN*											
9. Affected Ramp-Stow											
10. Affected AICS CB-Cycle (LF2 or LG2)											
Warning: If Caution Wing Sweep Fault is *Present, Cycling Right AICS CB May Cause* Wings to Sweep											
11. Inlet Ramp-Auto											
12. If Inlet Fault Remains, Stay < 0.9 IMN											
Inlet Ice				X							
1. Anti-Ice Switch - Oride											
2. When Clear of Icing Cond, Select Auto											
Ladder Unlatched					X						
1. Airspeed-Minimum											
2. Airborne Visible Inspection if Feasible											
3. Land ASAP											
Launch Bar						X					
On Ground Take Appropriate Action											
In Flight-Do Not Retract Landing Gear											
Land ASAP											
Mach Trim							X				
1. Master Reset-Depress											
2. Use Manual Trim											
Nav Computer Failure								X			
1. Switch to IMU (NFO)											
NWS Engaged									X		
If NWS is Not Desired, Depress Button on Stick Grip to Disengage NWS											

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	LN1 OVSP	RN_1 OVSP	L St Valve	R St Valve	L Oil Hot	R Oil Hot	L Oil Press	R Oil Press	ARI
Inactive	OC	OC	OC	OC	OC	OC	OC	OC	OC
Active	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	28 vdc	Gnd A/C	Gnd A/C	28 vdc
Remote Warning Indication									
Master Caution	X	X	X	X	X	X	X	X	X
L (R) N_1OVSP 1. Throt Affected Engine - Idle 2. *Nozzle Position - Check* 3. Avoid Hi Power-Settings 4. Land ASAP	X	X							
L (R) St Valve If Airborne 1. Air Source - Off 2. Eng Crank Sw - Off 3. If Fault remains - Land ASAP 4. If fault goes away, Air Source - Both 5. Land ASAP Caution: With Air Source Off, Stay Below 300 KIAS/0.8 IMN If On Deck 1. Air Source - Off 2. Throt - Affected Engine - Off			X	X					
L (R) Oil Hot 1. Throttle Affected Engine - As High Fuel Flow as Practical 2. Induce Slight Left Sideslip (R Rudder) 3. If Fault Remains After 1 Min, Throttle-Off 4. Land ASAP 5. Relight Engine for Ldg if Necessary					X	X			
L (R) Oil Press. Low (Affected Engine) 1. Oil Press. 40 PSI at MIL, Throttle - Idle 2. Oil Press. 35 PSI at Idle, or Engine Vibration, Throttle - Off 3. If Shutdown Not Feasible, Set 78% RPM 4. Avoid High G or Large Throttle Movements 5. Land ASAP							X	X	
ARI Engaged Disengage if Not Desired									X

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs / MMD Outputs	Wshld Hot	Yaw Stab. Op	Yaw Stab. Out	IMU	Cabin Press.
Inactive	OC	4.5 vdc	4.5 vdc	Gnd (A/C)	OC
Active	28 vdc	0 vdc	0 vdc	OC	28 vdc
Remote Warning Indication					
Master Caution	X	X	X	X	X
MMD Fault & Course of Action					
Windshield Hot	X				
1. Wshld Switch - Off					
2. Air Source - Off (Below 35,000 Ft) If Fault Remains After Air Source is Off, Indication is Faulty. Turn ECS on & Land ASAP					
3. Ram Air - INCR (< 300 KIAS/0.8 IMN)					
4. Land ASAP					
Yaw Stab. OP		X			
1. Master Reset - Depress					
2. If Fault Remains, Stay Below 0.93 IMN					
YAW STAB. OUT			X		
1. Yaw Stab. - Off					
2. Master Reset - Depress If Fault Goes Away - Reengage Yaw Stab. If Fault Remains - Stay Below 0.93 IMN					
IMU Failed (NFO)				X	
1. Switch to AHRS					
Cabin Press. (NFO)					X
1. Oxy Mask - ON					
2. Cycle Press. Switch					

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs	Comb Hyd Press.	Flt Hyd Press.
Inactive	OC	OC
Active	28 vdc	28 vdc
MMD Outputs		
Remote Warning Indication		
Master Caution	X	X
Flt Hyd Press. Low		X
If Approx 2100 PSI		
1. Wing Sweep – 20°		
2. Right Ramp (< 0.9 IMN) - Stow		
3. Emerg Flt Hyd - High (Just Prior to Dirty-Up)		
Equip Inop: Normal Hook - Restored by WOW		
4. Land ASAP		
Note: Arrested Landing Requires Emerg Hook Ext		
If Approx 0 PSI		
1. Bi-Direct Pump - OFF		
2. Wing Sweep - 20°		
3. Emerg Flt Hyd Sw - High (Just Prior to Dirty-Up)		
4. Equip Inop: R Glove Vane, ACLS, R AICS, and Norm Hook (Restored by WOW)		
5. Land ASAP		
NOTE: Arrested Ldg Requires Emerg Hook Ext		
Comb Hyd Press. Low		
If Approx 2100 PSI		
1. Hyd Isol - Flt	X	
NOTE: Monitor Aux Brks Gage, Tap Wheel Brake to Seat Priority Valve if Press. is Decreasing		
2. Wing Sweep - 20°		
3. Left Ramp (< 0.9 IMN) - Stow		
4. Equipt Inop - None		
5. Emerg Flt Hyd - High (Just Prior to Dirty-Up)		
6. Land ASAP		
If Approx 0 PSI		
1. Bi-Direct Pump - Off		
2. Wing Sw - 20°		
3. Equip Inop: L AICS, L Glove Vane, Emerg Gen, Aux Flaps, Inbd Spoilers, NWS, Gun Drive, DLC, Spd Brks, Norm Hook, Hook Extend*, Flaps/Slats*, Ldg Gear*, Wheel Brakes*, Refuel Probe*		
* Emerg Actuation Available		
4. Emerg Flt Hyd - High (Just Prior to Dirty-Up)		
5. Wheels - Emerg DN		
6. Flaps/Slats - DN (No Aux Flap)		
7. Hook - Emerg DN		
8. Brake Hand Pump - Check		
9. Anti Skid/Spoiler Bk - Spoiler Bk (Off for CVA)		
10. Arrest Land ASAP		
After Landing:		
11. Engines - Off		
Stay in Arresting Gear		

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

Flaps Inactive: Sat. Trans Active: Cutoff Trans	MMD Inputs / MMD Outputs
	Remote Warning Indication
X	**Master Caution**
	MMD Fault & Course of Action
X	**Flap/Slat Malfunction**
	After Raising Handle-Flaps/Slats Not Indicating Up
	1. Remain below 225 KIAS
	2. Master Reset-Depress
	3. Maneuver Flap Thumbwheel-Full Forward
	If Fault Remains
	4. FLAP Handle-Emerg Up
	After Raising Flap Handle-Flaps/Slats Indicate Up
	1. Remain Below 225 KIAS
	2. Master Reset-Depress
	3. Maneuver Flap Thumbwheel-Full Forward
	If Fault Remains:
	4. Flaps-Cycle
	If Flaps Respond:
	5. Master Reset-Depress
	If Fault Remains:
	6. Attempt to Sweep Wings to 25° (Manual Mode).
	If Wings Will Not Sweep Aft of 20, Both Aux Flaps are not Retracted & Limit Switches Are Not Made:
	7. Remain Below 0.7 IMN (Maneuver Flaps & Auto Retract May be Inoperative)
	If Wings Will Sweep Aft of 20°:
	8. Accelerate to 300 KIAS.
	9. Attempt Wing Sweep Aft of 50° (Manual Mode).
	If Wings Will Not Sweep Aft of 50°, Main Flaps Are Not Fully Retracted:
	10. FLAP Handle-Emerg Up
	11. Reattempt to Sweep Wings Aft of 50
	If Wings Still Will Not Sweep Aft of 50°:
	12. Remain Below 0.8 IMN.
	Note
	If wings sweep aft of 50°, aircraft flight envelope is unrestricted. Maneuver flaps & auto retract may be inoperative.
	After Lowering Flap Handle-Flap/Slats Not Indicated Down:
	1. FLAP Handle-Emerg Down
	After Lowering Flap Handle-Flap/Slat Indicating Down:
	1. Wing Sweep-Check at 20° (Allow 10 Sec for Auxiliary Flaps to Extend)
	2. Master Reset-Depress

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs →	FLAPS (Cont'd)	Asymmetry Flap/Slap Lockout
Inactive: Sat. Trans / OC		
Active: Cutoff Trans. / 28 vdc		
MMD Outputs ↓		
Remote Warning Indication		
Master Caution	X	X
MMD Fault & Course of Action		
Flap/Slat Malfunction If Fault Remains: 3. Normal Landing Note Flap light may be caused by failure of auxiliary flaps to extend, increasing approach speed approximately 5 knots After Using Maneuvering Devices 1. Master Reset - Depress 2. Maneuvering Flap Thumbwheel - Full Forward If FLAP Fault Remains: 3. FLAP Handle - Emerg Up If Flaps Indicate Up: 4. Wing Sweep - Aft of 50° (manual mode) If Wings Will Not Sweep Aft of 50° 5. Remain Below 0.8 IMN Note If wings will sweep aft of 50°, aircraft flight envelope is unrestricted. Maneuver flaps and auto retract will be inoperative.	X	
ASYMMETRY FLAP/SLAT LOCKOUT Warning Asymmetric flap extension can produce an uncontrollable rolling moment. The following procedures defeat the designed asymmetry protection and therefore should be used when a shipboard landing is the only alternative and flap extension is required to remain within arresting gear limits. 1. Airspeed - Maintain Less Than 225 KIAS 2. Maintain Wings - Level Flight 3. Aux Flap/Flap Çontr CB - NFO PUll (7G3) Warning Failure to pull the AUX FLAP/FLAP CONTR cb before completing the following steps may result in an uncontrollable pitch trim change due to auxiliary flap extension or retraction. 4. Flap Handle - Corresponding to Indicator Caution Placing the FLAP handle in either the full extend or retract position may result in damage because the overtravel switch will be disabled.		X

TABLE A-1 MMD INPUTS VS OUTPUTS (CONT'D)

MMD Inputs:	Wing Sweep (2)	Wing Sweep (1)	Wing Sweep	Asymmetry Flap/Slat Lockout (Cont'd)	MMD Outputs
Inactive	A/C Gnd	Sat. Trans	A/C Gnd	OC	
Active	OC	Cutoff Trans	OC	28 vdc	
	X	X			**Remote Warning Indication**
			X	X	**Master Caution**
					MMD Fault & Course of Action
				X	**Asymmetry Flap/Slap Lockout (Cont'd)**
					5. Flap/Slat Contr Shutoff CB - Cycle (RE2)
					6. Slowly Move Flap Handle Toward Desired Position
					If Flaps/Slats Respond, Nuisance Lockout Has Been Eliminated
					7. Aux Flap/Flap Contr CB - NFO Reset (7G3)
					8. Master Reset - Depress
					If Flaps/Slats Do Not Respond:
					7. Reposition Flap Handle to Match Indicator
					8. Flap/Slat Contr Shutoff CB - Pull (RE2)
					9. Slowly Move Flap Handle Toward Desired Position
					If Aircraft Rolls:
					10. Move Flap/Slats Back to Where No Rolling Exists
					If Aircraft Does Not Roll:
					10. Stop Flap/Slat Travel Before Reaching Full Up or Full Down
					Caution
					With the Flap/Slat Contr Shutoff CB Pulled.
					No Overtravel Protection for the Flap/Slats Exists
					11. Flap/Slat Contr Shutoff CB - Reset (RE2)
					12. Land Utilizing 15 Units AOA
			X		**Wing Sweep**
					1. Master Reset - Depress
					2. If Fault Remains, One Channel Has Failed
	X	X			**Wing Sweep - Both Ch Failed**
					No Auto/Man. Control
					1. Airspeed - Decel to $<$ 0.9 IMN
					2. Check Spider Detent Engaged
					3. Master Reset - Depress
					Wait 15 Sec - If Warn Indication Remains
					4. Wing Sweep CB (2) - Pull (Wg Sw Drive No. 1 & 2, LE1, LE2)
					5. Emerg Wing Sweep Handle - Comply With:
					$<$ 0.4 IMN - 20°
					$<$ 0.7 IMN - 25°
					$<$ 0.8 IMN - 50°
					$<$ 0.9 IMN - 60°
					$>$ 0.9 IMN - 68°
					Caution - Avoid ACM & Aerobatics
					-Before Ldg Use Flap Overtravel Position
					To Insure Flaps Remain Fully Extended

TABLE A-2 CATEGORIZATION OF FAULTS BY SYSTEM

01	Warning Sys	
	L (R) Fire	(W)
	Wing Sweep	(W)
	Wheels	(W)
	Reduce Speed	(W)
	Brakes	(W)
02	Fuel Sys	
	L (R) Fuel Low	(C)
	L (RO Fuel Press	(C)
	Bingo	(C)
03	CADC Sys	
	CADC	(C)
	Flaps	(C)
	Asym Fl/Sl Lockout	(C)
	Glove Vane	(C)
	Wing Sweep	(C)
04	Elect. Power	
	L (R) Gen	(C)
	Trans/Rect	(C)
05	Eng. Instr.	
	L (R) N. OVSP	(C)
	L (R) Strt Valve	(C)
	L (R) Oil Hot	(C)
	L (R) Oil Press	(C)
06	AICS Sys	
	L (R) Ramps	(C)
	L (R) Inlet	(C)
07	Hyd Sys	
	Flt Hyd Press	(C)
	Comb Hyd Press	(C)
08	Environ Contr Sys	
	Bleed Duct	(C)
	Oxy Low	(C)
	Cabin Press	(C)
09	Flt Contr Sys	
	Rudder Auth	(C)
	Spoilers	(C)
	Auto Pilot	(C)
	Yaw Stab Op	(C)
	Yaw Stab. Out	(C)
	Pitch Stab 1 (2)	(C)
	Roll Stab 1 (2)	(C)
	Hz Tail Auth	(C)
	Mach Trim	(C)
	A/P Ref	(C)
	ACLS/AP	(C)
10	Airframe Sys	
	Ladder	(C)
	Launch Bar	(C)
	Canopy	(C)
	NWS Engaged	(C)
11	Nav Sys	
	Nav Comp	(C)
	AHRS	(C)
	IMU	(C)
12	Misc Sys	
	Integ Trim	(C)
	Wshld Hot	(C)
	Inlet Ice	(C)
	Auto Throt	(C)

Appendix B
F-14 AVIONIC BOILER PLATE SPECIFICATION

GRUMMAN AEROSPACE CORPORATION

Bethpage, L. I., N. Y.
Code Ident. No. 26512

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Specification No. F-14A-BP-68-1K

SPECIFICATION

Release Date 16 Sept. 1974

Superseding F-14A-BP-68-1J, dated 8-7-70.

AVIONIC BOILER PLATE AN/ (*)

DESIGN CONTROL SPECIFICATION FOR

F-14 WEAPON SYSTEM

Specifications Engr | Section

Cognizant Engr | A. Trabold Support Systems Mgr

Proj Engr

NAVPRO, Bethpage Engineering Date

Contract No.

Eng 200.1 7-66

List No. 37B

SPECIFICATION

No. F-14A-BP-68-1K

AVIONIC BOILER PLATE AN/ (*)

DESIGN CONTROL SPECIFICATION FOR

F-14 WEAPON SYSTEM

1 SCOPE

1.1 Scope. -

1.2 Classification. - The equipment covered by this specification shall meet the requirements of Specification MIL-E-5400 for Class 2 equipment except as modified herein. The equipment shall consist of the following:

Title	Type Designation (AN)	Para.

1.3 Associated Equipment. - The (name of equipment) shall operate with the associated equipment listed in 6.8.

2 APPLICABLE DOCUMENTS

2.1 Selection of Specifications and Standards. - Applicable publications shall be those contained in the LIST OF SPECIFICATIONS AND STANDARDS (Book Form) approved by the NAVAL AIR SYSTEMS COMMAND, NAVAIR 00-25-544, dated October 1966; other specifications in the Materials and Processing areas shall be those contained in the LIST OF SPECIFICATIONS AND STANDARDS (Book Form) approved by the NAVAL AIR SYSTEMS COMMAND, NAVAIR 00-25-544, dated May 1968; and the LIST OF STANDARD DRAWINGS used by the NAVAL AIR SYSTEMS COMMAND, NAVAIR 00-25-543, dated March 1967. Other applicable publications not contained in the above lists shall be the issue in effect on 1 May 1968, except as noted herein. All standards and specifications other than those established for use by the NAVAL AIR SYSTEMS COMMAND must be approved by the procuring activity prior to use as a part of this specification. When approved by the procuring activity, the seller may elect to use later issues of Government Documents when such effectivity results in an improvement in the state-of-the-art, material, processes, or resulting end item.

2.1.1 General. - The following documents of the exact issue shown form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-C-172B-2 Supplement 1C	Cases; Bases, Mounting; and Mounts Vibration (for use with Electronic Equipment in Aircraft)
MIL-C-675A-2	Coating of Glass Optical Elements (Anti-Reflection)
MIL-B-5087B(ASG)	Bonding, Electrical and Lightning Protection, for Aerospace Systems
MIL-W-5088C(ASG)	Wiring; Aircraft, Installation of
MIL-E-5272C(ASG)-1	Environmental Testing, Aeronautical and Associated Equipment, General Specification for

SPECIFICATION

No. F-14A-BP-68-1K

2.1.1 (Continued)

MIL-E-5400H	Electronic Equipment, Aircraft, General Specification for
MIL-T-5422E(ASG)-2	Testing, Environmental, Aircraft Electronic Equipment
MIL-I-6181D	Interference Control Requirements, Aircraft Equipment
MIL-C-6781B(ASG)	Control Panel Aircraft Equipment Rack or Console Mounted ASG
MIL-P-7788D	Panels, Information, Integrally Illuminated (see QPL-7788)
MIL-M-7793C-1 Supplement 1	Meter, Time Totalizing
MIL-C-8779B(WEP)-1	Colors, Interior, Aircraft, Requirements for
MIL-T-18303A(WEP)	Test Procedures; Preproduction and Inspection, for Aircraft Electronic Equipment, Format for
MIL-N-18307C(ASG)-3	Nomenclature and Nameplates for Aeronautical Electronic and Associated Equipment
MIL-P-23377B-1	Primer Coating, Epoxy Polyamide Chemical and Solvent Resistant
MIL-C-26482D	Connectors, Electric, Circular, Miniature, Quick Disconnect
MIL-S-38130A	System Safety Engineering of Systems and Associated Subsystems and Equipment; General Requirements for
MIL-H-46855	Human Engineering Requirements for Military Systems, Equipment and Facilities

2.1.1 (Continued)

MIL-L-81352(AS)-1	Lacquer; Acrylic (For Naval Weapons)
MIL-C-0081511D	Connector, Electric Circular High Density Quick Disconnect, Environment Resisting, Specification for

Naval Air Systems Command

AR-5A	Microelectronic Devices Used in Avionics Equipment, Procedures for Selection and Approval of

STANDARDS

Federal

FED-STD-595	Colors

Military

MIL-STD-202C Notice 2	Test Method for Electronic and Electric Component Parts
MIL-STD-454A	Standard General Requirements for Electronic Equipment
MIL-STD-471	Maintainability Demonstration
MIL-STD-704A	Electric Power, Aircraft Characteristics and Utilization of

2.1.1 (Continued)

Military

MIL-STD-781A	Reliability Tests-Exponential Distribution
MIL-STD-810B	Environmental Test Method for Aerospace and Ground Equipment
MS17322 Rev. C	Meter, Time Totalizing, Miniature Digital, 115 Volt, 400 Hz
MS25271(ASG) Rev. C	Relay, 10 Amp. 4 PDT Class B-8 Sealed, with Solder Hooks

HANDBOOKS

Military

MIL-HDBK-5A and Change 1	Metallic Materials and Elements for Aerospace Vehicle Structure
MIL-HDBK-23 and Change 1, Part I	Composite Construction for Flight Vehicles, Part I - Fabrication, Inspection, Durability and Repair
Part II	Sandwich Construction for Aircraft, Part II
Part III	Composite Construction for Flight Vehicles, Part III - Design Procedures

PUBLICATIONS

NAVAIR 00-25-543 dated March 1967	List of Standard Drawings
NAVAIR 00-25-544 dated October 1966 and May 1968	List of Specifications and Standards

SPECIFICATION

No. F-14A-BP-68-1K

2.1.2 Grumman. - The following documents of the issue in effect at the time of invitation to bid form a part of this specification to the extent specified herein:

SPECIFICATIONS

A51CST010	Thermal Requirements for Sellers, General Specification for F-14A Weapon System Avionics
A51CSH011	Human Factors Requirements for Sellers, General Specification for F-14 Weapon System
* A51CSW012	Weight Control Requirements for Sellers, General Specification for F-14A Weapon System
A51CSM013	Maintainability Program Requirements for Sellers, Avionics, General Specification for F-14A Weapon System
A51CSE016	Electromagnetic Interference Control Requirements for Sellers, General Specification for F-14A Weapon System
A51CSR017	Reliability Program Requirements for Sellers, General Specification for F-14A Weapon System
A51CSC018	Configuration Management Requirements for Sellers, General Specification for F-14A Weapon System
A51CSV022	Versatile Avionic Shop Test (VAST) Requirements for Sellers, General Specification for F-14A Weapon System
A51CSV023	Versatile Avionic Shop Test Program Sets General Requirements for F-14A Weapon System
A51CSV024	VAST Baseline Specification General Requirements for F-14A Weapon System

2.1.2 (Continued)

SPECIFICATIONS

A51CSF025	Control Panel Standardization Requirements for Sellers General Specification for F-14A Weapon System
*A51CSW027	Basic Weights Control Requirements for Sellers, General Specification for F-14A Weapon System
A51CSR033	Electrical, Built-In Test (BIT) Indicators Standardization, Requirements, General Specification for F-14A Weapon System

*NOTE: Check with weights, if A51CSW012 or A51CSW027 should be used.

DRAWINGS

Grumman

A51A____________

2.1.3 Availability of Documents. -

(a) When requesting military specifications, standards, drawings, and publications, refer to both title and number. Copies of applicable specifications required by contractors in connection with specific procurment functions may be obtained upon application to the Commanding Officer, Naval Supply Depot, Code 105, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

(b) Copies of this specification or applicable Grumman Documents may be obtained from Grumman Aerospace Corporation, Bethpage, Long Island, New York 11714; Attention: F-14 Subcontracts Manager.

3 REQUIREMENTS

3.1 Preproduction (Qualification). - This specification makes provision for preproduction testing.

3.2 Parts and Materials. - In the selection of parts and materials, fulfillment of major design objectives shall be the prime consideration. In so doing, the following shall govern:

(a) Microelectronic devices shall conform to requirements specified herein.

(b) Other parts and materials requirements shall conform to Specification MIL-E-5400, paragraph 3.1 and Specification A51CSR017, paragraph 3.2.2.7.3.

(c) For design purposes, data and properties of materials shall be obtained from Handbooks MIL-HDBK-5, MIL-HDBK-23, or from other sources subject to approval of the procuring activity.

3.2.1 Nonstandard Parts and Materials Approval. - Approval for the use of nonstandard parts and materials (including electron tubes, transistors and diodes) other than microelectronic devices shall be obtained as outlined in Specification MIL-E-5400. Microelectronic devices shall be approved as outlined in Specification AR-5, as modified by Specification A51CSR017, paragraph 3.2.2.7.3.4.

3.2.2 Microelectronic Modular Assemblies. - Microelectronic modular assemblies shall meet the requirements of Specification AR-5 as modified by Specification A51CSR017, paragraph 3.2.2.8.

3.2.3 Finishes. - The exterior finish shall meet the requirements of Specification MIL-E-5400 and as follows:

(a) The cleaning and metal treatments shall meet the requirements of Specification MIL-E-5400.

(b) Apply Epoxy primer, in accordance with Specification MIL-P-23377.

3.2.3 (Continued)

(c) Apply Acrylic lacquer, in conformance with Specification MIL-L-81352.

(d) Equipments located in the cockpit shall be flat dull black Standard FED-STD-595 No. 37038. Colors of all panels, knobs, bezels and controls shall be in accordance with Specification MIL-C-8779. In other areas the color shall be flat dark grey in accordance with Standard FED-STD-595 No. 36231.

3.2.4 Magnesium and Magnesium Alloys. - Magnesium and magnesium alloys shall not be used.

3.3 Design, Construction and Workmanship. - The equipment shall conform with all the applicable requirements of Specification MIL-E-5400, paragraph 3.2 and Drawing A51A__________ for design and construction. Workmanship shall conform to Specification MIL-E-5400, paragraph 3.5.

3.3.1 Total Weight. - The total weight of the equipment, excluding cables, shall be a minimum consistent with good design and shall not exceed ___ pounds. The seller shall conduct a weight control program in accordance with Specification (A51CSW012 or A51CSW027).

3.3.2 Reliability Provisions. -

3.3.2.1 Reliability Program Requirements. - During the design, development and production phases of the contract, the seller shall conduct an organized reliability program implementing as a minimum, those requirements contained in Specification A51CSR017 and this specification.

3.3.2.2 Quantitative Reliability Requirements. -

3.3.2.2.1 Mean-Time-Between-Failures (MTBF). - The specified MTBF as defined in Standard MIL-STD-781, paragraph 3.1, shall be ___ hours.

3.3.2.2.2 Operating Life. - The equipment shall have a total operating life of ____ hours. Parts requiring replacement during this interval shall be identified by the seller and submitted to the procuring activity for approval in accordance with the requirements of Specification A51CSR017.

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3.3.2.2.3 Elapsed Time Indicators. - Time totalizing meters in accordance with Standard MS17322, as specified in Specification MIL-M-7793, shall be included in each Weapons Replaceable Assembly. Meter location shall be selected by the seller and submitted to the procuring activity for approval.

3.3.3 Cabling and Connectors. -

3.3.3.1 Cables and Connectors. - The equipment shall provide for the use of cables and connectors in accordance with Specification MIL-E-5400, paragraphs 3.1.5 and 3.1.36. WRA interface connectors shall conform to Specification MIL-C-0081511 or MIL-C-26482.

3.3.3.2 Interconnection Cabling. - The equipment shall be capable of satisfactory operation using external wiring in accordance with the requirements of Specification MIL-W-5088 and paragraph 3.1.36 of Specification MIL-E-5400. The external wiring shall be unshielded, except that a minimum number of the individual wires may be shielded when demonstrated by the seller as necessary to meet interference control requirements, provided internal EMI suppression is not possible, and the assembly of the cable to its plugs may be easily accomplished. External cables and that portion of the connectors attached to the cables shall not be supplied as part of the equipment.

3.3.4 Control Panels. - All control panels, whether rack or control console mounted shall conform to the applicable requirements of Specification MIL-C-6781 for Type I and II control panels. Provision shall be made for integrally illuminated panels in accordance with Specification MIL-P-7788, Type IV, Class 1R. The configuration of all panels must be approved by the procuring activity prior to preproduction testing. Panels shall be designated in accordance with Specification A51CSF025.

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3.3.5 Interchangeability. - The equipment shall meet the interchangeability requirements of Specification MIL-E-5400, paragraph 3.3.

3.3.6 Electromagnetic Interference (EMI) Control. - The generation of EMI by the equipment and the susceptibility of the equipment to EMI shall be controlled within the limits specified in Specification MIL-I-6181 and as specified herein. During the design, development and production phases of the contract, the seller shall comply as a minimum with those requirements contained in Specification A51CSE016.

3.3.6.1 Conducted and Radiated Emissions. - The conducted and radiated emissions of the equipment shall be controlled within the limits and requirements specified in 4.3.1.2.

3.3.6.2 Conducted and Radiated Susceptibility. - There shall be no problems, such as, malfunction, change in normal indication or degradation of performance of the equipment when subjected to the tests and requirements specified in 4.3.1.2.

3.3.7 Maintainability. - Maintainability requirements shall be as specified in this specification. The maintainability program for accomplishing these requirements shall be in accordance with requirements of Specification A51CSM013.

3.3.7.1 Detail Maintainability Requirements. - The following maintainability requirements and packaging requirements of Specification A51CSM013 shall be demonstrated in accordance with __________________ herein.

3.3.7.1.1 Preventive Maintenance. - Avionic equipment generally shall not have preventive maintenance requirements. Any requirements for preventive maintenance shall be justified, documented and submitted to the procuring activity for approval.

3.3.7.1.2 Corrective Maintenance. - The maintenance rate (MR) for corrective maintenance shall be the determining factor in measuring and evaluating the following requirements. The maintenance rate shall be established from the following:

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3.3.7.1.2 (Continued)

MR = (OH/FH X M/F X Failure Rate) + (OH/FH X Wearout Rate)

Where:

OH = Number of operating hours

FH = Number of flight hours

M = Number of Corrective Maintenance Actions

F = Number of failures

The failure rate and wearout rate shall be obtained from the contractually required reliability prediction. Generally the OH/FH ratio is 2.0 and the M/F ratio is 3.0. Any deviation from these ratios shall be justified, documented and submitted to the procuring activity for approval.

3.3.7.1.2.1 Organizational Level. - Organizational level maintenance shall generally consist of performance of fault detection, isolation to WRA, removal and replacement of WRA from aircraft and operational verification. The following requirements shall be accomplished:

(a) Built-in-test (BIT) shall be incorporated into the equipment to enable unambiguous fault isolation to the defective WRA in a meantime of less than _____ minutes and a maximum time of less than_______minutes. BIT shall be provided to detect and unambiguously isolate at least________% of all possible equipment faults, when the faults are ranked by frequency of occurrence.

(b) No support equipment shall be used. Requirements for support equipment of any type shall be justified, documented and submitted to the procuring activity for approval.

(c) Removal and replacement of the WRA shall not exceed _____ minutes (exclusive of access time).

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3.3.7.1.2.1 (Continued)

(d) The total corrective maintenance time, the summation of fault isolation, removal and replacement and verification shall not exceed ____ minutes meantime. Ninety percent of all corrective maintenance actions shall be completed within _____ minutes.

3.3.7.1.2.2 Intermediate Level. - The equipment to which this specification applies shall be designed for compatibility with the Versatile Avionic Shop Test (VAST) System AN/USM-247 as described in Specifications A51CSV022 and A51CSV023. VAST Test Programs shall be furnished in accordance with Specification A51CSV024.

(a) WRA Repair - Restoration shall consist of fault isolation to the defective Shop Replaceable Assembly (SRA), removal and replacement and/or in place repair of the defective SRA, and verification that the specific WRA performance level of operation has been restored. Fault isolation to the defective SRA shall be accomplished without ambiguity, using only those test points of 3.3.7.2.4. Any requirement for fault isolation to more than one SRA shall be subject to approval by the procuring activity. Fault isolation by exception to the Inplace Repairable Assembly (IPRA) shall be permitted. Removal and replacement of a defective SRA shall not require the use of special tools or processes.

(b) SRA Repair - The probability of restoring a malfunctioned repairable SRA to an acceptable level of performance shall be 0.98. Restoration shall consist of fault isolation to the defective part or nonrepairable component, removal and replacement of the item and verification that the specific SRA performance level of operation has been restored. Fault isolation shall be accomplished using only those test points of 3.3.7.2.4. Further fault isolation to the defective part(s) may be accomplished using special test points provided for that purpose. Removal and replacement or repair of the defective part shall not require use of special tools or processes.

3.3.7.1.2.2 (Continued)

(c) Total Corrective Maintenance - The following total corrective maintenance times shall be satisfied:

(1) The summation of removal and replacement of defective SRA and the removal and replacement and/or repair of a defective part(s) including access and secure time, shall not exceed ____ minutes meantime and ____ minutes maximum at the 90th percentile.

(2) The total time to test on VAST, the summation of fault isolation and verification that the malfunction has been restored for the WRA and SRA including hookup, warmup, turn-off and unhook time, shall not exceed _____ minutes meantime.

3.3.7.1.2.3 Depot Level. - Avionic equipment generally shall not have depot level maintenance requirements. Any requirements for depot maintenance shall be justified, documented and submitted to the procuring activity for approval.

3.3.7.2 General Maintainability Requirements. -

3.3.7.2.1 Task Criteria. - Each of the maintenance times listed in 3.3.7.1.2 are to be accomplished with a maximum of one maintenance personnel of no higher than intermediate skill (E-4) for at least 95% of the maintenance tasks.

3.3.7.2.2 Built-In Test. - Suitable BIT features shall be incorporated into the equipment to provide GO/NO-GO indications of equipment readiness, and when a fault is detected, automatically locate the fault to the malfunctioning WRA. The BIT shall be self-contained and independent of external signals that normally interface with the equipment. These features shall be such as to energize warning devices (indicators) for each WRA when equipment performance falls below a specified level.

NOTE: Select either of the following 3.3.7.2.2.1 depending upon automatic or manual BIT requirements.

3.3.7.2.2.1 Operation. - BIT operation shall be automatic and continuous to detect and isolate to the malfunctioning WRA. The BIT shall be such as to energize fault devices after there is reasonable assurance that the equipment performance has fallen below a specified level. For each WRA a fault indicator and a discrete output GO/NO-GO signal for remote indication, shall be provided. Failure of any external equipment, or any abnormal interference signal, shall not cause BIT to indicate a failure.

3.3.7.2.2.1 Operation. - BIT operation shall be initiated by a manual switch located on the front of the equipment and also by an input signal from a remote location. The BIT shall be such as to energize fault devices after there is reasonable assurance that the equipment performance has fallen below a specified level. For each WRA a fault indicator and a discrete output GO/NO-GO signal for remote indication shall be provided. Failure of any external equipment, or any abnormal interface signal shall not cause BIT to indicate a failure.

3.3.7.2.2.2 Fault Detection Provisions. - A latch type indicator (mechanical reset) shall be provided in accordance with Specification A51CSR033 for each WRA to indicate, with power removed or interrupted, whether any NO-GO test result occured since the last mechanical reset.

3.3.7.2.2.3 Fail-Safe Operation. - The circuits and devices which provide self-test functions shall be designed in such a manner that any failure of the self-test circuitry will not degrade the equipment with which it is associated.

3.3.7.2.3 WRA, SRA Interchangeability. - Any SRA of this equipment, after having its performance verified at the intermediate/depot level of maintenance, when inserted into the WRA shall not require or cause the WRA or any SRA within the WRA to be adjested or calibrated. No adjustments will be permitted on the WRA at any level of maintenance. When inserted into the aircraft, it also shall not cause other WRA's or SRA's to be adjusted

3.3.7.2.4 Test Points. - Test points shall satisfy the following requirements:

(a) Functional Test Point Arrangement - Test points shall be exposed and grouped within a multipin connector which is readily accessible at the level of maintenance for which it is intended. All external test point connectors shall be provided with metal caps chained to the equipment. The test points shall be grouped by the functional maintenance level requirements as follows:

(1) WRA test points for intermediate/depot.

(2) SRA test points for intermediate/depot.

(b) The test points shall be located as follows:

(1) WRA test points shall be located in such positions to be readily accessible for maintenance while installed in the aircraft.

(2) SRA test points shall be located in such positions to be readily accessible for maintenance actions. The majority of these test points shall be located on the outer surface of the SRA at specifically identified jacks or on test connectors themselves.

3.3.7.2.4.1 WRA Test Points. - Test points are required on each WRA for maintenance at the intermediate/depot level for use when the WRA is removed from the aircraft or is newly issued, to determine the performance level of the WRA and, in the event of a failure to identify which SRA is at fault. WRA test points shall, when used in conjuction with the operational connector, provide the means for:

(a) Measuring the necessary input/output parameters to enable isolation of faulty SRA's in accordance with 3.3.7.1.2.2.

(b) Ascertaining WRA performance criteria, in such a manner that when an WRA is reinstated in the system, the system will meet the performance criteria.

(c) Implementing a master reset of all elements within the WRA to a predetermined state or known condition.

3.3.7.2.4.2 SRA Test Points. - Test points are required on each SRA for use when the SRA has been removed from the WRA to ascertain which component is at fault. SRA test points should provide the means for:

(a) Measuring the necessary input/output and circuit parameters to enable isolation to the faulty nonrepairable or small group of nonrepairables as follows:

3.3.7.2.4.2 (Continued)

(a) (Continued)

(1) When the SRA contains 10 or fewer nonrepairables, isolation to groups of 2 or less shall be possible for 50 percent of the possible faults. Isolation to 4 or less must be possible for all possible faults.

(2) When the SRA contains more than 10 nonrepairables, isolation to groups of 4 or less shall be possible for 80 percent of the possible faults. Isolation to groups of 8 or less must be possible for 95 percent of the possible faults. Isolation to groups of 10 or less must be possible for 100 percent of the possible faults.

(b) Measurement of necessary input/output parameters to enable calibration or alignment of the SRA.

3.3.8 Nomenclature and Nameplates. - Nomenclature assignment and nameplate approval for equipment identification shall be in accordance with Specification MIL-E-5400, paragraph 3.4, and Specification MIL-N-18307.

3.3.8.1 Identification and Marking. - Identification and marking shall be in accordance with Specification MIL-E-5400, paragraph 3.1.19 and Specification A51CSC018.

3.3.9 Standard Conditions. - The following conditions shall be used to establish normal performance characteristics and for making laboratory bench tests:

Temperature	Room ambient (25 $\pm$ 5°C)
Altitude	Normal ground
Vibration	None

3.3.9 (Continued)

Humidity	Room ambient up to 90% relative humidity
Input power voltage	115 $\pm$ 1.0 VAC 400 $\pm$ 20 Hz and/or 27.5 $\pm$ 0.5 VDC

3.3.10 Service Conditions. - The equipment shall operate satisfactorily under any of the environmental service conditions or reasonable combination of these conditions as specified in paragraph 3.2.21 of Specification MIL-E-5400 for Class 2 equipment, except as modified herein.

3.3.10.1 Temperature and Altitude. - The equipment shall operate satisfactorily when subjected to the requirements of paragraph 3.2.21.1 and 3.2.21.3 of Specification MIL-E-5400 and Figure 1 of Specification A51CST010. The transient conditions of Figure 1 of Specification A51CST010 do not apply to cabin equipment.

(a) Environment A of Figure 1 of Specification A51CST010 defines the temperature-altitude requirements for equipment located within conditioned compartments.

(b) Environment B of Figure 1 of Specification A51CST010 defines the temperature-altitude requirements for equipment located within nonconditioned compartments.

The following equipments shall be located in environment A:

(1)

(2)

The following equipments shall be located in environment B:

(1)

(2)

3.3.10.2 Vibration. - The equipment shall satisfactorily meet the performance requirements of this specification when subjected to the vibration inputs of Curves I and II, Figure 5 of Specification MIL-E-5400.

3.3.10.2.1 Design Stiffness Requirements. -

(a) Minimum Design Resonant Frequencies - No resonant frequency of the equipment, or any of its components (excluding external and/or internal isolation systems, if any), shall be below 45 Hz.

(b) Minimum Design Resonant Amplification Factor - A minimum resonant amplification factor of ten shall be assumed in the design analysis. Lower factors may be assumed (subject to the approval of the procuring activity) if damped laminate construction or other structural damping methods are used.

3.3.10.2.2 Vibration Isolation. - When external and/or internal vibration isolators are used, the mounting system shall be in compliance with Specification MIL-C-172, with the following exceptions.

3.3.10.2.2.1 Transmissibility and Resonant Frequencies. - The transmissibilities of the mounting system shall not exceed the allowable values given in Figure 3.1 herein, in any direction of vibration. Resonant frequencies, whether coupled or uncoupled, are not restricted within specific limits; rather they are limited only to the extent that the transmissibilities associated with the resonant frequencies, do not exceed the allowable values.

3.3.10.2.2.2 Configuration. - Unit vibration isolators or distributed elastic media of any size, shape or material (including flexible plastic foam) may be used provided the volume and form factors of the installation are in compliance with Drawing ____________.

3.3.10.3 Shock. - The equipment shall be capable of meeting the performance requirements when subjected to the shock inputs of Specification MIL-E-5400, paragraph 3.2.21.6. The shaped pulse of these shocks shall be a half sine wave.

3.3.10.4 Acceleration. - The equipment shall be capable of meeting the performance requirements when subjected to the acceleration inputs of Specification MIL-E-5272, paragraph 4.16.3, Procedure III.

3.3.11 Service Conditions - Electrical. -

3.3.11.1 Primary Input Power Requirements. - The equipment shall meet all applicable requirements of Standard MIL-STD-704 and shall give specified performance from the following power sources with characteristics as defined in Standard MIL-STD-704 having limits specified therein. The power required shall not exceed the specified amounts.

(a) AC Power (Three Phase) 115/200 V, Category B _____ VA.

(b) 28 VDC Category B, ______ watts.

* 3.3.11.2 Degraded Performance. - The equipment performance during abnormal power conditions as defined by Standard MIL-STD-704 shall be as follows.

** 3.3.11.3 Warm-Up Time. - Warm-up time under standard conditions shall not exceed ___ minutes and ___ minutes under service conditions.

3.3.12 Surrounding Air Pressure. - For design purposes, the air pressure surrounding the equipment shall be assumed equivalent to free stream static pressure. All newly developed equipment shall be designed to satisfactorily withstand or operate at 0.65 psia surrounding air pressure.

3.3.12.1 Cabin Equipment. -

(a) Normal 21.0 to 2.73 psia

* If equipment performance is other than that stated during abnormal power conditions listed in Standard MIL-STD-704, para. 6.4, see cognizant engineer for details. If performance is acceptable as stated in para. 6.4 delete 3.3.11.2.

** Delete, if warm-up time is same as that of Specification MIL-E-5400, para. 3.2.20.1.

3.3.12.1 (Continued)

(b) Abnormal — 2.73 to 0.65 psia for periods up to 10 minutes duration. Degradation of performance will be allowed but the equipment shall sustain no permanent damage as a result of exposure to this condition.

3.3.12.2 Remote and In-Bay Equipment. - The equipment shall be designed to operate at 15.5 to 0.65 psia, and the surrounding air pressure may vary at rates as high as 0.25 psi per second.

3.3.12.3 Transient Characteristics. -

3.3.12.3.1 Cabin Equipment. -

(a) Normal - The surrounding air pressure may vary at a rate as high as 0.25 psi per second.

(b) Abnormal (Explosive Decompression) -

Condition I - The equipment shall meet functional requirements (including accuracy requirements) immediately after being subjected to an explosive decompression in which the surrounding air pressure varies with time in accordance with the curve specified as Condition I of Figure 3.2 (cabin pressure decay during explosive decompression).

Condition II - The equipment shall not deform or disintegrate in a manner which could cause injury to a crew member or otherwise jeopardize aircraft safety when subjected to an explosive decompression in which the surround air pressure varies with time in accordance with the curve specified as Condition II of Figure 3.2. (Cabin pressure decay during explosive decompression.) The equipment shall not be required to function after experiencing this condition.

3.3.13 Thermal Requirements and Cooling. - The equipment shall meet the thermodynamic requirements specified in Specification A51CST010.

3.3.13 (Continued)

Specification A51CST010 is provided to assist the seller with the thermal design evaluation to assure that the equipment will operate satisfactorily without adjustment under all modes of operation in the weapon system.

3.3.13.1 Heat Dissipation. - The heat dissipation Q_e (electrical heat generated within the unit) shall not exceed the following:

Equipment	Heat Dissipation - Watts
(a)	
(b)	

3.3.13.2 Forced Air Cooled Equipment. - The cooling requirements for forced air cooled equipment shall not exceed 2.32 lbs/min/kw (w/Q_t*) for conditions defined herein:

(a)	Ambient Temperature	160°F
(b)	Cooling Air Inlet Temperature	60°F
(c)	Surrounding Air Pressure	14.7 psia

* Q_t = Cooling air duty as defined by Specification A51CST010.

3.3.14 Human Factors Engineering. - The requirements for applying the principles and criteria of human factors engineering shall conform to Specifications MIL-H-46855 and A51CSH011.

3.3.15 Configuration Management. - Articles furnished in accordance with this specification shall be developed and produced under a system of Configuration Management as specified in Specification A51CSC018.

3.3.16 Bonding. - The equipment shall be bonded in accordance with Specification MIL-B-5087, paragraphs 3.3.3 and 3.3.5.

** 3.3.17 Safety. - The equipment shall be designed to preclude the incorporation of features which result in critical or catastrophic hazards as classified in paragraph 3.2.3 of Specification MIL-S-38130.

** NOTE: Choose one paragraph 3.3.17 as determined by the requirements of AVO VFX-ENG/A51-340-A-68-1, dated 20 Nov. 1968.

** 3.3.17 Safety. - The equipment shall be designed to preclude the incorporation of features which result in critical or catastrophic hazards as classified in paragraph 3.2.3 of Specification MIL-S-38130. Analyses of the equipment design shall be performed in accordance with paragraphs 3.4, 3.4.1, 3.4.2 and 3.4.3 of Specification A51CSS031.

** 3.3.17 Design Safety. - The equipment shall conform to all the requirements of Specification A51CSS031.

3.3.18 Coverglass and Wedges. - The instrument coverglass and any other transparent element between the glass and dial such as a lighting wedge shall be provided with a reflection reducing coating that meets the requirements of Specification MIL-C-675, in addition to withstanding the environmental conditions of the indicator involved, except that the following reflectance tolerances shall apply:

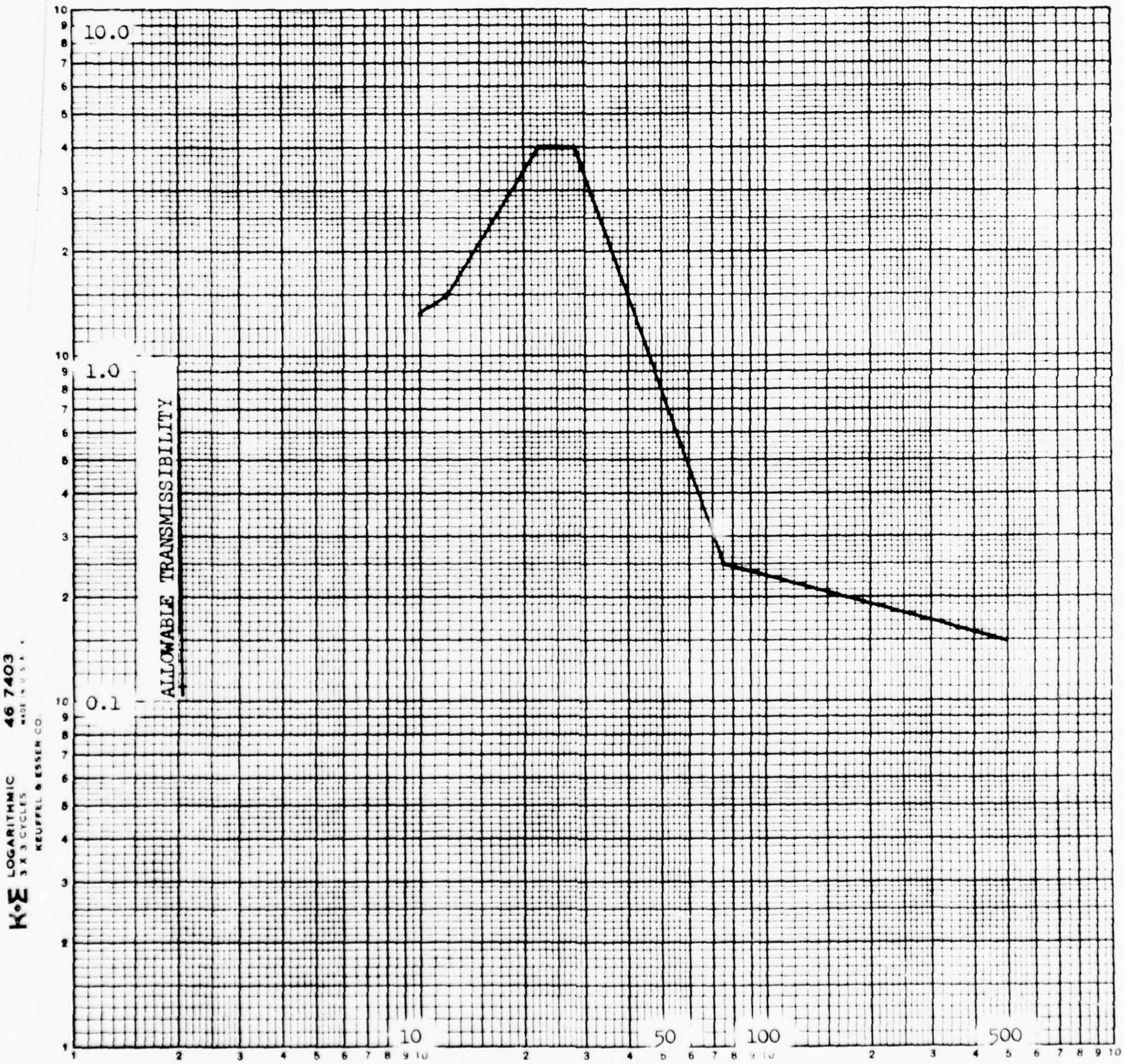
Angle of Incidence	Wavelength Millimicrons	Percent Reflectance
0°	450 - 675	0.6 Absolute
0°	425 - 700	0.5 Average
30°	450 - 675	1.0 Absolute
30°	425 - 700	0.5 Average

3.4 Performance. - Unless otherwise specified, values set forth to establish the requirements for satisfactory performance apply to performance under both standard and environmental service conditions. When reduced performance under the environmental conditions is acceptable, tolerances or values setting forth acceptable variations from the performance under the standard conditions will be specified.

3.5 Detail Requirements. -

** NOTE: Choose one paragraph 3.3.17 as determined by the requirements of AVO VFX-ENG/A51-340-A-68-1, dated 20 Nov. 1968.

ENVELOPE OF ALLOWABLE TRANSMISSIBILITY



FREQUENCY - Hz

FIGURE 3.1

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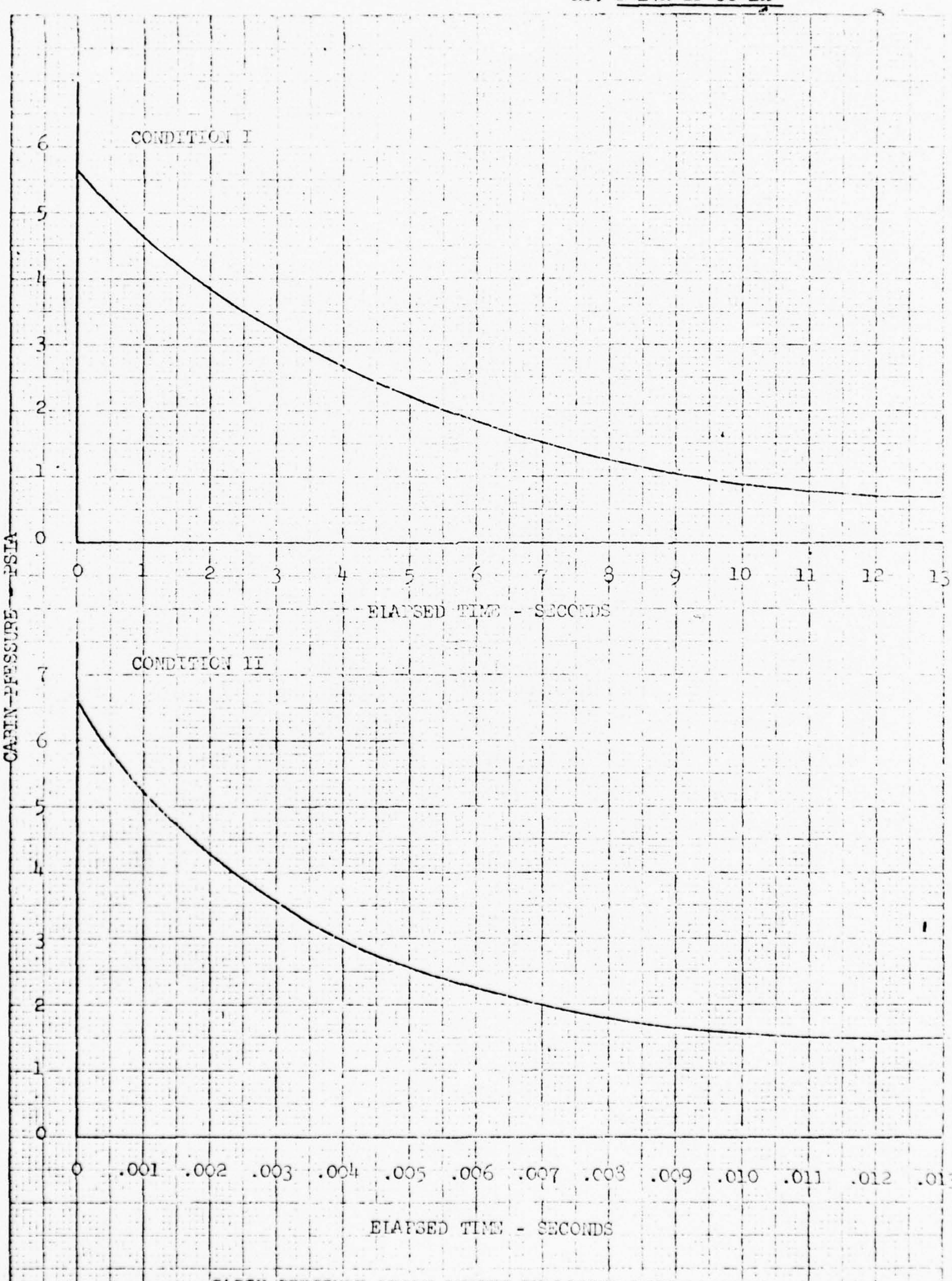

CABIN PRESSURE DECAY DURING EXPLOSIVE DECOMPRESSION

FIGURE 3.2

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4 QUALITY ASSURANCE PROVISIONS

4.1 Seller's Quality Program. - Articles furnished in compliance with this specification shall be produced under the controls established in the Seller's (See Definitions, Section 6) Quality Program Plan. The plan shall be prepared and submitted to the procuring activity.

4.2 Responsibility for Inspections and Tests. - Unless otherwise specified in the contract or purchase order, the seller shall be responsible for the performance of all inspections and tests specified herein. All procedures, tests, data and reports generated, conducted, provided, and submitted in accordance with the requirements of this specification shall be consistent with the definitions and ground rules contained in Section 6. The seller shall utilize the facilities of a laboratory acceptable to the procuring activity and the Government. The procuring activity reserves the right to re-perform any of the inspections and/or tests set forth in this specification where such are deemed necessary to assure that supplies and services conform to prescribed requirements. The procuring activity and the Government Inspector shall be advised two weeks in advance when tests are to be conducted so that representatives may be designated to witness or supervise the tests when so desired. In addition, the procuring activity reserves the right to witness the tests and disassembly conducted by the seller on nonconforming articles returned by the procuring activity.

4.2.1 Classification of Tests. - Items covered by this specification shall be subjected to the following tests to determine compliance with all applicable requirements:

(a) Preproduction Tests (Qualification)

(b) Acceptance Tests (Quality Conformance)

(c) Special Tests

Acceptance of articles under the test provisions specified herein shall not relieve the seller of responsibility to meet the design requirements of the specification.

4.3 Preproduction Tests (Qualification). - Preproduction tests shall be made on equipments representative of the production equipments to be supplied under the contract. Preproduction tests shall be accomplished under the approved test procedure of 4.7.

NOTE: When preproduction tests are to be made on equipments manufactured in the first production run, the equipments to be tested shall be selected by a representative of the procuring activity with the concurrence of the Government Inspector.

4.3.1 Scope of Preproduction Tests. - Preproduction tests shall include all tests specified herein and shall be conducted in accordance with the requirements of this specification. Test values and parameters shall be as designated in the design requirements paragraphs of this specification. If during the course of conducting preproduction tests corrective action is required, the seller shall re-evaluate the previously approved tests, test plans, and test procedures to assure their continued validity. The corrective action, extent of required retest, and the test plan and procedure revisions shall be subject to approval of the procuring activity. Preproduction tests shall consist of the following:

(a) Acceptance (Quality Conformance) Tests

(b) EMI Tests

(c) Environmental Tests

(d) Reliability Demonstration Tests

(e) Maintainability Demonstration Test

(f) VAST Compatibility Demonstration Test

(g) Human Factors Engineering Verification Test

4.3.1 (Continued)

NOTES: (1) During preproduction testing of the applicable equipments, Micro Integrated Circuit Replaceable Assembly (MICRA) from the two acceptable sources shall be employed in the test specimen. MICRA from the second source shall be used in applications having the same environmental-operational stresses imposed upon them as do MICRO from the first source.

(2) When tolerances are specified in the applicable referenced specifications/standards, these tolerances shall include the instrumentation error.

4.3.1.1 Acceptance (Quality Conformance) Inspection. - The acceptance tests shall consist of the tests of 4.4.1 and shall be performed on all preproduction equipment.

4.3.1.2 Electromagnetic Interference (EMI) Test Requirements. - The seller shall demonstrate compliance to 3.3.6 by meeting the requirements and performing the tests specified herein. During susceptibility testing, when a problem is found, the seller shall determine and record the threshold of susceptibility that causes the problem. The threshold shall be defined in terms of frequency, amplitude or distance from unit cable or cable bundle as may be applicable for the configuration under test. Test shall be performed with harnesses that simulate aircraft configuration as to length, gage, shields grounding, etc. The test set up shall not be disassembled unless approved by the procuring activity. The system shall be tested to these requirements in all modes of operation.

4.3.1.2.1 Test Requirements and Limits of Specification MIL-I-6181. - The equipment shall be subjected to the test requirements and comply with the limits of Section 4 of Specification MIL-I-6181.

4.3.1.2.2 Transient Conducted Interference Susceptibility. - Pulses, 50 volt amplitude both positive and negative polarity, shall be injected into each AC and DC power lead at a pulse repetition rate of 10 pps minimum for a period of at least 5 minutes for each pulse polarity. The characteristics of the transient pulse, as measured by an oscilloscope across the input terminal of the test sample (while the test sample is operating) shall follow the typical wave shape specified in Figure 4.1. Either series or parallel injection can be used as shown in Figure 4.2. Line stabilization networks shall be removed during these tests. If the equipment is found to be susceptible, the threshold of susceptibility shall be determined by decreasing the pulse amplitude.

4.3.1.2.3 Transient Radiated Interference Susceptibility. - The tests shall be performed in accordance with Figure 4.3. The relay used shall be Standard MS25271 or equivalent. No suppression shall be applied to the relay. The relay circuit shall be unshielded wire tightly coupled (taped) to, and in parallel with, the equipment power leads and signal leads, and tightly looped about the units of the equipment comprising the test sample. The test shall be performed first with the double pole double throw (DPDT) switch in position A, then with the DPDT switch in position B. The test shall be run for a period of at least five minutes in each switch position. If the unit is susceptible, the threshold of susceptibility shall be determined by moving the relay circuit wire away from the bundle or case.

4.3.1.2.4 Induction Field Interference Susceptibility. -

4.3.1.2.4.1 Cable Bundle Test and Requirements. - Tape two (2) insulated, unshielded wires to each cable bundle of the test sample, 90 degrees apart. The current carrying wires shall run the entire length of the bundle under test, and as close as possible to each end connector. Apply 20 amperes of AC current at a frequency of 400 Hz to each wire, one at a time. See Figure 4.4 for the test set-up. All cable bundles shall be 2 inches minimum above ground plane. AC power leads may be exempt from this test. The test shall be for a period of at least 5 minutes for each switch position. If the unit is susceptible, the threshold of susceptibility shall be determined by decreasing the current in the current carrying wire and then by moving the current (20A) carrying wire away from the bundle

4.3.1.2.4.2 Case Test and Requirements. - Wrap one turn of insulated, unshielded wire around each unit case in the test sample. This single turn of wire shall be centered and held in place by tape. Apply 20 amperes of AC current at a frequency of 400 Hz. See Figure 4.5 for the test set-up. The test shall be run for a period of at least five minutes. If susceptible, the threshold of susceptibility shall be determined by decreasing the current.

4.3.1.2.5 Radiated Field Interference Susceptibility. - This requirement supersedes the RF radiated susceptibility requirement in Specification MIL-I-6181. The cables and units comprising the test sample shall be subjected to a 1.0 volt per meter field in the frequency range of 0.155 MHz to 20 GHz. The modulation of the RF signal shall be those rates and indices for which the test sample is most susceptible. The specified field strength shall be established by placing a calibrated antenna at the same distance or relative location where the test sample will be placed. The power at the input terminals of the transmitting antenna

4.3.1.2.5 (Continued)
required to establish the specified field shall be monitored and recorded. When a test is performed, this same amount of power shall be applied to the transmitting antenna terminal. When baluns or other matching networks are used, any losses shall be properly compensated. If susceptible, the threshold of susceptibility shall be determined by reducing the field intensity.

4.3.1.3 Environmental. - The following environmental tests shall be performed in accordance with Specification MIL-T-5422 for Class 2 equipment except as modified herein. Prior to, during and after each environmental test, readings shall be taken to determine that the operational limits of this specification are met, with the exception of salt spray, shock, sand and dust, explosion and fungus for which readings shall be taken only at the start and finish of each test.

4.3.1.3.1 Temperature and Altitude. - The equipment shall operate satisfactorily within a temperature-altitude environment specified in Specification MIL-T-5422, Class 2 paragraph 4.1 modified by Specification A51CSF010. The cooling performance, moisture, high flow and thermal shock tests of Specification A51CSF010 shall be performed as part of this test. All control panels shall be removed from the tested assembly for this temperature altitude test and shall be subjected only to the tests and limits of Specification MIL-C-6781, paragraph 4.1, for qualification purposes.

4.3.1.3.2 Vibration. - The equipment shall be tested in accordance with paragraph 4.2, Curve I and Curve II from Figure 2 of Specification MIL-T-5422 and as follows.

4.3.1.3.2.1 Vibration Test. - The specified vibration input shall be sinusoidal at the nominal frequency. The input shall be applied to and monitored at the interface between the test fixture and each equipment mounting point. A complete record of each vibration test shall be established, including all resonant frequencies detected with associated amplification factors, instrumentation used, and details regarding the performance of the equipment under test. The input to all mounting points shall be at least the levels of the applicable curve or as approved by the procuring activity.

4.3.1.3.2.2 Resonant Dwell Frequencies. - Resonant dwell frequencies shall be defined as those frequencies at which the vibration is most likely to cause structural failure or malfunction of the test item. The most severe dwell frequencies need not always coincide with resonant frequencies.

4.3.1.3.2.3 Vibration Fixtures. - The test fixture shall transmit the specified sinusoidal vibration input from the shaker armature to the equipment mounting points with minimum attenuation, amplification or distortion. Transverse motion, in any direction, measured at the equipment mounting points should be less than 100% of the applied vibration. Compliance with the above requirements shall be demonstrated by performing a fixture survey in each axis with the test specimen, normally mounted; however, input levels shall not exceed 20% of the levels specified by Curve I of Specification MIL-T-5422.

4.3.1.3.3 Shock. - The equipment shall be tested in accordance with paragraph 4.3 of Specification MIL-T-5422. The shock pulse shall be a half-sine wave as defined by paragraph 3.1 from Method 213 of Standard MIL-STD-202. Instrumentation used to record the input pulse shall be in accordance with paragraph 2.2, Method 516 of Standard MIL-STD-810. The amplitude of the shock pulse shall be $\pm$ 10% of the level indicated.

4.3.1.3.4 Humidity. - The equipment shall be tested in accordance with paragraph 4.4 of Specification MIL-T-5422 as modified by Specification A51OSTO10. A rapid operational check, such as a BIT check, shall be conducted once during the low temperature portion of each cycle. During checkout, specially cooled equipment shall receive cooling air at the appropriate temperature and flow rate. At the completion of the humidity test a complete checkout of the equipment shall be performed.

NOTES: (1) The use of a Dewpoint indicator for verification of relative humidity is preferred. Differential temperature (wet vs. dry) or separate wet and dry bulb measurements having the required resolution are acceptable. Differential temperature is preferred over separate wet and dry bulb readings.

(2) If a wet bulb sensor is used, the air flow past the sensor shall be at least 900 feet per minute. Both the dry bulb and wet bulb sensor shall be located in the same air stream. The dry bulb sensor shall be located beside or upstream from the wet bulb sensor.

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4.3.1.3.5 Acceleration. - The equipment shall be tested in accordance with paragraph 4.16.3, Procedure III of Specification MIL-E-5272. Tolerance on radial acceleration shall be ± 10% at the center of gravity of the equipment.

4.3.1.3.6 Salt Spray. - The equipment shall be tested in accordance with paragraph 4.5 of Specification MIL-T-5422.

* 4.3.1.3.7 Explosion. - The equipment shall be tested in accordance with paragraph 4.6 of Specification MIL-T-5422.

4.3.1.3.8 Sand and Dust. - The equipment shall be tested in accordance with paragraph 4.7 of Specification MIL-T-5422.

4.3.1.3.9 Fungus. - The equipment shall be tested in accordance with paragraph 4.8 of Specification MIL-T-5422.

** 4.3.1.3.10 Explosive Decompression. - The equipment shall be subjected to tests simulating cabin blowout conditions resulting from the explosive decompression rates for Conditions I and II as shown in Figure 3.2. During these tests, the chamber and equipment internal pressure variations shall be recorded. At the conclusion of each test the equipment shall meet the applicable operating requirements as specified in 3.3.12.3.1.

4.3.1.4 Reliability Demonstration. - Preproduction tests shall include reliability demonstration in accordance with Standard MIL-STD-781, Qualification Phase Test Level F. Test Plan ___ and the cycling requirements of Figure 1 of Standard MIL-STD-781 as modified by Specification A51CSR017.

4.3.1.5 Maintainability Demonstration. - A maintainability demonstration shall be made on preproduction equipments in accordance with the sellers approved maintainability demonstration plan, prepared in accordance with Standard MIL-STD-471, Test Plan A and B, Method 1 and Specification A51CSM013.

* Delete for cabin equipment.

** Delete for other than cabin equipment.

4.3.1.6 VAST Compatibility Demonstration. - The VAST compatibility demonstration shall be performed in accordance with Specification A51CSV022.

4.3.1.7 Human Factors Engineering Verification Test. - A human factors engineering verification test shall be performed to demonstrate compliance with the applicable human factors engineering specifications. The effect of degraded inputs and degraded performance shall be determined.

4.3.2 Preproduction Test Report. - The seller shall submit to the procuring activity, for approval, copies of his preproduction test report. The report shall include the test results, all supporting data collected in conducting the tests, and analyses of all failures which occurred. As a supplement the seller may include, for the procuring activity's consideration, any recommendations for design improvement beyond the corrective action required to pass the test. The data presentation of the test report shall be coordinated with the approved test procedure required by 4.7.

4.3.3 Preproduction Approval. - Satisfactory completion of the preproduction test requirements shall be contingent upon the procuring activity's approval of the seller's preproduction test report. Fabrication of production equipment prior to such approval is at the seller's own risk. After completion of the tests, the disposition of the equipments tested shall be as specified in the contract.

4.4 Acceptance Tests. - Acceptance tests shall be performed to verify that equipments supplied under the contract meet the standards established in Section 3, and are equivalent to the preproduction test equipments in all respects, including design, construction, workmanship, test performance and quality. Acceptance or approval of material during the course of manufacture shall not be construed as a guarantee of its acceptance in the finished product. All equipments shall have satisfactorily passed the applicable acceptance tests prior to delivery. No deliverable equipment shall have accrued more than 20% of its operating life (including all test and check out time) when received by the procuring activity. If, during testing, 20% of the useful life of a limited life item is exceeded (based on the previously established replacement schedule), those items must be replaced prior to shipment to the procuring activity and a final functional

4.4 (Continued)

performance check must be satisfactorily completed. Evidence of noncompliance with the above shall constitute cause for rejection. For noncomplying equipment already accepted, it shall be the obligation of the seller to designate the necessary corrections and incorporate them after approval by the procuring activity. (Also see 4.8.1).

4.4.1 Scope of Acceptance Tests. - Acceptance tests are categorized as follows:

(a) Individual Tests

(b) Reliability Acceptance

(c) Final Operational Test

4.4.1.1 Individual Tests. - Individual tests shall be conducted on each equipment submitted for acceptance under the contract, and shall consist of the tests specified herein.

4.4.1.1.1 Examination of Product. - Each equipment shall be examined during appropriate stages of manufacture and assembly to determine compliance with Requirement 9 of Standard MIL-STD-454 and the applicable drawings.

4.4.1.1.2 Initial Operational Test. - The operational tests shall establish that the equipment, when operated in accordance with the approved test procedures of 4.7, and under the Standard Conditions of 3.3.9, meets the applicable design requirements. Before test measurements are taken, each equipment shall be operated continuously for at least one-half hour after its thermal stabilization temperature (See Section 6) has been reached. Once the time to reach thermal stabilization has been established, the temperature measurements need not be repeated on subsequent equipments.

4.4.1.1.3 Manufacturing Run-In Test. - Manufacturing run-in tests shall be performed to eliminate manufacturing defects from equipment before subjecting the equipment to further tests. Each equipment shall be operated under the same environmental and cycling conditions as specified in 4.4.1.2 for a period of 100 "ON" hours.

4.4.1.1.3.1 Test Duration. - Each basic test cycle shall be repeated until the required number of operating hours has been achieved. Accrued test time is not required to be continuous, i.e., time out to repair the equipment and verify the repair effectiveness in the event of failure, shall be allowed but shall not count towards accrued burn-in time. Failures occurring during the manufacturing run-in duration shall not generally count against the reliability assessment of the equipment. The seller shall, however, determine if the problem is due to workmanship or is design oriented, and take appropriate corrective action.

4.4.1.2 Reliability Acceptance Test. - The equipment shall be operated and the critical performance monitored under the following environmental conditions, in accordance with the sellers approved test plan and the cycling requirements of Figure 1 of Standard MIL-STD-781 as modified by Specification A51CSR017.

(a) Temperature	-54°C to +71°C
(b) Vibration	Any non-resonant frequency between 54 and 75 Hz at 1.5 g's. (To be applied for 10 minutes of each hour of equipment ON time.)

4.4.1.2.1 Basic Reliability Acceptance Test. - The equipment shall operate ___ consecutive failure free "ON" hours under the above environmental conditions. The test period shall be extended to a maximum of ____ hours until the failure free period is achieved. If ___ hours of test time is reached without successful completion of the failure free period, the equipment shall be deemed unacceptable, subjected to positive corrective action with the concurrence of the procuring agency and resubmitted for acceptance under the provisions of this paragraph.

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4.4.1.2.2 Reduced Reliability Acceptance Test. - When failure history during RAT for the last 10 equipments shows that the observed MTBF meets or exceeds the specified MTBF the ___ failure free "ON" hours in a maximum of ___ "ON" hours as specified above, may be reduced to ___ and ___ hours respectively, subject to procuring activity's approval. The procuring activity reserves the right to revert to the Basic Reliability Acceptance Test whenever field failure experience is deemed unsatisfactory. The Basic Reliability Acceptance Test shall be automatically re-instated whenever the combined MTBF (measured during RAT) of the last 10 units subjected to the Reduced Reliability Acceptance Test falls below the specified MTBF.

4.4.1.3 Final Operational Test. - The operational tests required in 4.4.1.1.2 shall be repeated after the equipments have passed all prior acceptance tests. The equipments shall perform within the prescribed tolerances during both tests. Any significant variations between the data obtained in the two tests of a given equipment shall be investigated by the seller and the results of such investigation reported to the procuring activity. A failure detected during final operational tests shall be charged against RAT, and shall require re-running RAT unless the seller can establish that the failure did not occur in RAT.

4.4.2 Acceptance Test Data. - The seller shall furnish reports with each shipment, showing quantitative results for all acceptance tests. Each report shall identify the unit by part number and serial number, and shall be signed by an authorized representative of the seller. Accrued operating time shall be reported (See 4.5).

4.5 Special Tests. - Changes in design and material subsequent to completion of the preproduction tests may require additional or revised testing of the equipments involved. Such tests as are directed by the procuring activity for the purpose of evaluating the changes on the performance and quality of the revised equipments are classified as special tests.

4.5.1 Scope of Special Tests. - Test procedures previously approved for the preproduction tests shall be used where applicable. When not applicable, the seller shall prepare a test procedure and submit it to the procuring activity for approval prior to conducting the tests.

4.5.2 Special Test Schedule. - Special tests shall be made as follows:

(a) As soon as deemed practicable by the procuring activity after an engineering or material change.

(b) Whenever failure reports or other information indicate that additional tests are required. (This will be determined by the procuring activity.)

4.6 Equipment Failure. - The term failure shall be as defined in Section 6. Should a failure occur during any of the acceptance or special tests specified herein, the following action shall be taken:

(a) Immediately notify the procuring activity's representative.

(b) Prepare a malfunction report, noting suspected cause, and submit to procuring activity.

(c) Determine the cause of failure.

(d) Determine if the failure is a recurring manufacturing problem or design deficiency.

(e) Submit analysis to the procuring activity.

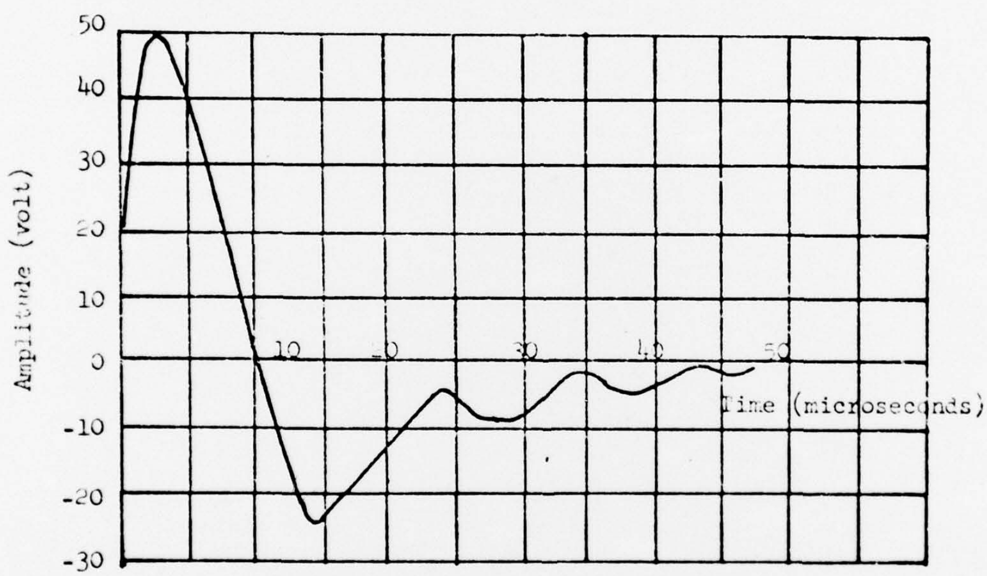
(f) Submit to the procuring activity for approval the proposed corrective action intended to reduce the possibility of the same failure(s) recurring.

4.6.1 Correction Validation. - When a failure occurs during acceptance or special tests, the individual test requirements schedule shall include a test to check all equipment for the noted nonconformance until it has been determined that the defect has been satisfactorily corrected.

4.7 Test Procedures. - The procedures used for conducting preproduction tests and acceptance tests shall be prepared by the seller and submitted to the procuring activity for approval. The right is reserved by the procuring activity to modify the tests or to require any additional test procedure or details deemed necessary to determine compliance with the requirements of this specification. The test details, such as fixture design, the length of the test cycle, the length of heat portion of the cycle, the performance characteristics to be measured, special failure criteria, preventive maintenance to be allowed during the test, thermocouple and accelerometer locations, instrumentation description, etc., shall be part of the test procedures to be submitted. In addition, the test procedures shall include a list of limited life items with their replacement schedules. Specification MIL-T-18303 shall be used as a guide for the preparation of test procedures.

4.8 Rejection and Retest. - Equipment which has been rejected may be reworked, or have parts replaced to correct the defects, and resubmitted for acceptance. Before resubmittal, full particulars concerning previous rejection and the action taken to correct the defects found in the original shall be furnished to the procuring activity. After corrections have been made, all tests deemed necessary by the procuring activity shall be repeated.

4.8.1 Defects in Items Already Accepted. - When investigation of a test failure indicates that like defects exist or could exist in items already accepted, the seller shall so advise the procuring activity, designate the necessary corrections and incorporate them after approval by the procuring activity.

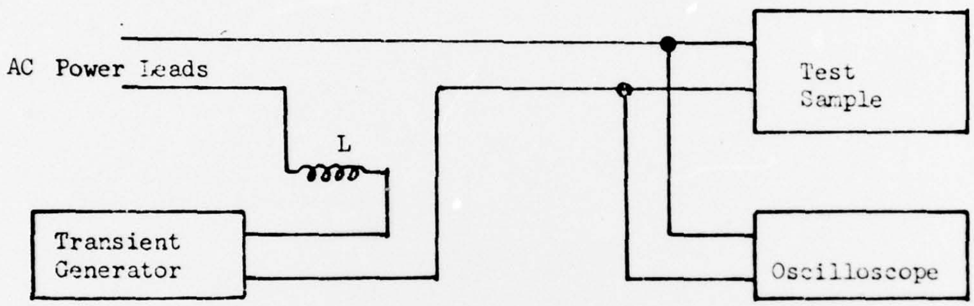


Typical injected spike at input to test sample

FIGURE 4.1

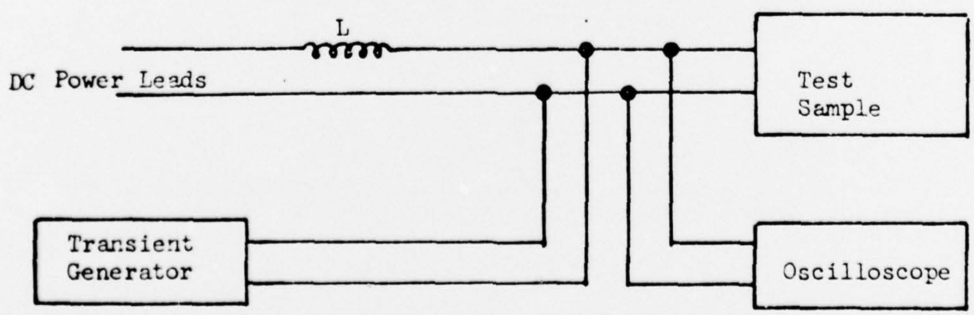
Pulse Characteristics, Transient Conducted Interference Susceptibility

a. Series Injection Test Setup



L = 20 microhenries

b. Parallel Injection Test Setup



L = 20 microhenries

FIGURE 4.2

Transient Conducted Interference Susceptibility

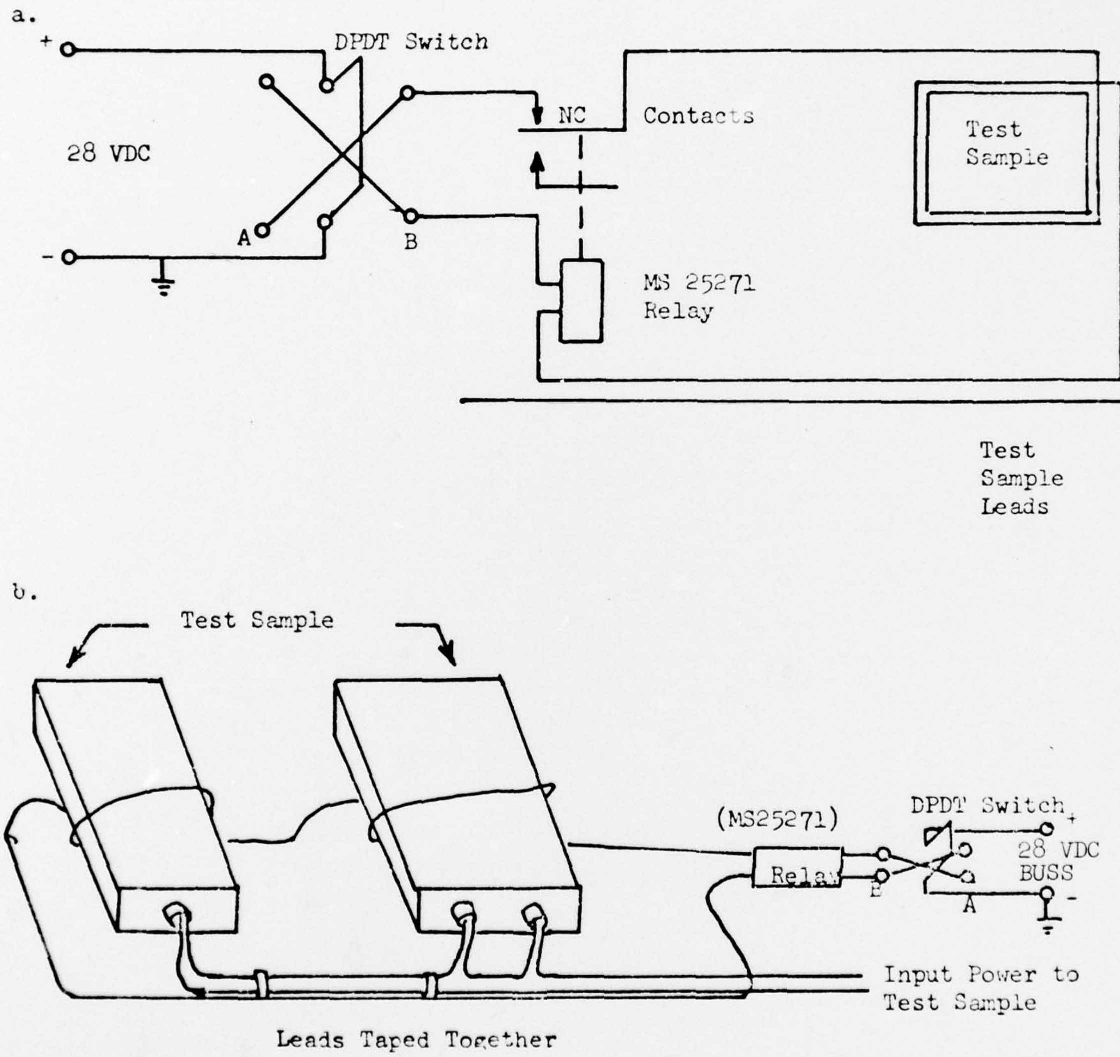
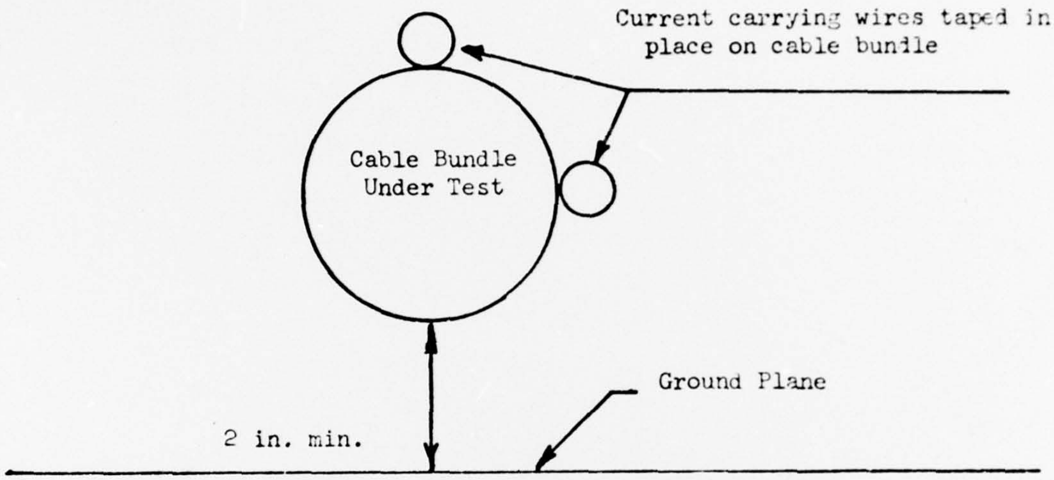


FIGURE 4.3

Transient Radiated Interference Susceptibility a.



b.

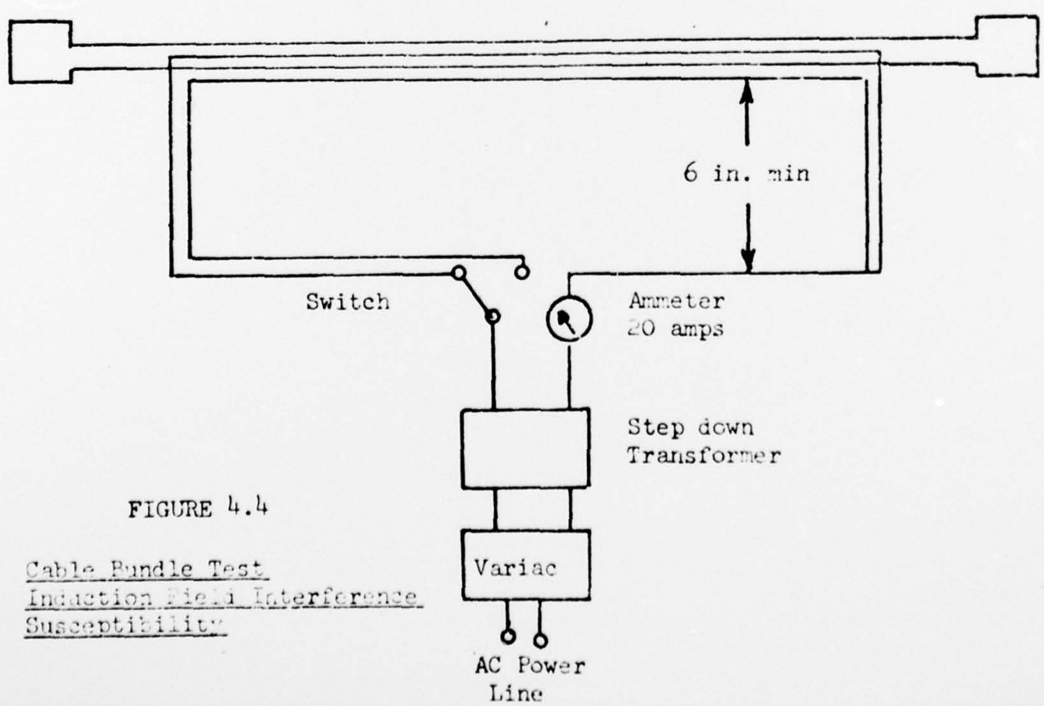


FIGURE 4.4

Cable Bundle Test
Induction Field Interference
Susceptibility

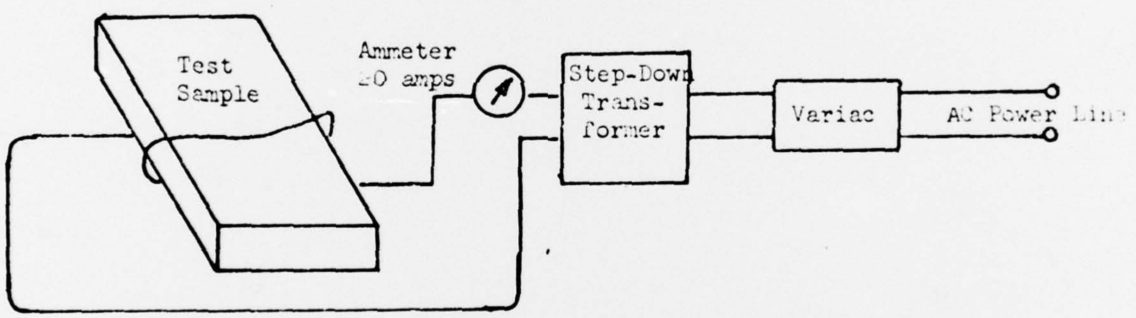


FIGURE 4.5

Case Test

Induction Field Interference Susceptibility

5 PREPARATION FOR DELIVERY

5.1 General. - All major units and parts of the equipment shall be preserved, packaged, packed and marked for the level of shipment specified by the procuring activity.

6 NOTES

6.1 Intended Use. -

6.2 Ordering Data. - Purchasers should exercise any desired options offered herein, and procurement documents should specify the following:

(a) Title, number, and date of this specification.

(b) Selection of applicable levels of packaging and packing (See 5.1).

6.3 Precedence of Documents. - When the requirements of the contract, this specification, or applicable subsidiary specifications are in conflict, the following precedence shall apply:

(a) Contract - The contract shall have precedence over any specification.

(b) This Specification - This specification shall have precedence over all applicable subsidiary specifications. Any deviation from this specification, or from subsidiary specifications where applicable, shall be specifically approved in writing by the procuring activity.

(c) Referenced Specifications - Any referenced specification shall have precedence over all applicable subsidiary specifications referenced therein. All referenced specifications shall apply to the extent specified.

6.4 Performance Objectives. - Minimum size and weight, simplicity of operation, ease of maintenance, and an improvement in the performance and reliability of the specific functions beyond the requirements of this specification are objectives which shall be considered in the production of this equipment. Where it appears a substantial reduction in size and weight or improvement in simplicity of design, performance, ease of maintenance or reliability will result from the use of materials, parts and processes other than those specified in Specification MIL-E-5400, it is desired their use be investigated. When investigation shows advantages can be realized, a request for approval shall be submitted to the procuring acitivity for consideration. Each request shall be accompanied by complete supporting information.

6.5 Definitions. -

(a) Procuring Activity - The procuring activity as referenced in this specification shall mean the Grumman Aerospace Corporation which is defined as the prime contractor procuring activity for the Naval Air Systems Command. The government procuring activity for the F-14 Weapon System is the Naval Air Systems Command, Washington, D.C.

(b) Seller - The seller is the agency responsible to Grumman for supplying the equipment described in this specification.

(c) Failure - A failure is the inability of an item to perform its required function within specified limits under specified conditions for a specified duration.

6.6 (Continued)

(d) Thermal Stability - Thermal stability is the conditions attained in an equipment when the rate of temperature change of its largest thermal mass becomes less than 2°C per hour or as specified in Specification MIL-T-5422.

(e) Non-Conformance - A condition of any article, material or service in which one or more characteristics do not conform to the specified requirements.

(f) Symbols - The symbol (*), when used in the type designation will be deleted or replaced by either a number or a letter upon assignment of nomenclature.

6.6 Testing Ground Rules. -

6.6.1 General Rules. - The following ground rules apply to the design verification, preproduction, acceptance, and special tests required herein, and supplement those found in the referenced specifications. See 6.6.2 for additional rules that apply to reliability assurance tests.

(a) A complete physical inspection and Quality Control sign-off shall be made prior to any test and after each removal and replacement of components during a test cycle.

(b) A survey shall be conducted on one unit prior to test to determine the time required to reach thermal stability. This shall be accomplished by monitoring a thermocouple located as closely as possible to the core of the item of greatest thermal inertia. The time required to reach cold soak temperature shall be determined with the equipment not operating. The time required to reach the upper operating temperature limit shall be determined with the equipment operating.

(c) Throughout the program and after every design change, the equipment being tested and the test fixture(s) shall be operated as integrated units to assure compatibility.

6.6.1 (Continued)

(d) The self-test provisions of the equipment under test shall be utilized to the maximum extent for determination of equipment performance during test, provided the monitoring means employed enables positive recognition of equipment failures.

(e) Anticipation of failure shall not be justification for preventive maintenance, i.e., if an output is observed to be degrading but is still within specification limits, no replacement or adjustment will be permitted unless such adjustments are normally made by means of crew operated controls.

(f) Normal flight line maintenance (adjustments, replacements of limited life items, etc.) shall be permitted only at periods specified in the maintenance manual for that specific equipment.

6.6.2 Reliability Demonstration Rules. - The following rules supplement those in 6.6.1 for reliability demonstrations.

(a) During the initial fixture/equipment compatibility check, operating time and failures shall be documented and the failures reported, but neither this time nor these failures shall be included in the reliability calculations.

(b) Operating time required to check the validity of repairs during the compatibility phase shall be documented but omitted from reliability calculations. This time shall not exceed 8 hours.

(c) Total test operating time per unit, including the time for fixture/equipment compatibility check, shall not exceed 20 percent of the equipment useful life. Items exceeding this limit shall be reported.

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